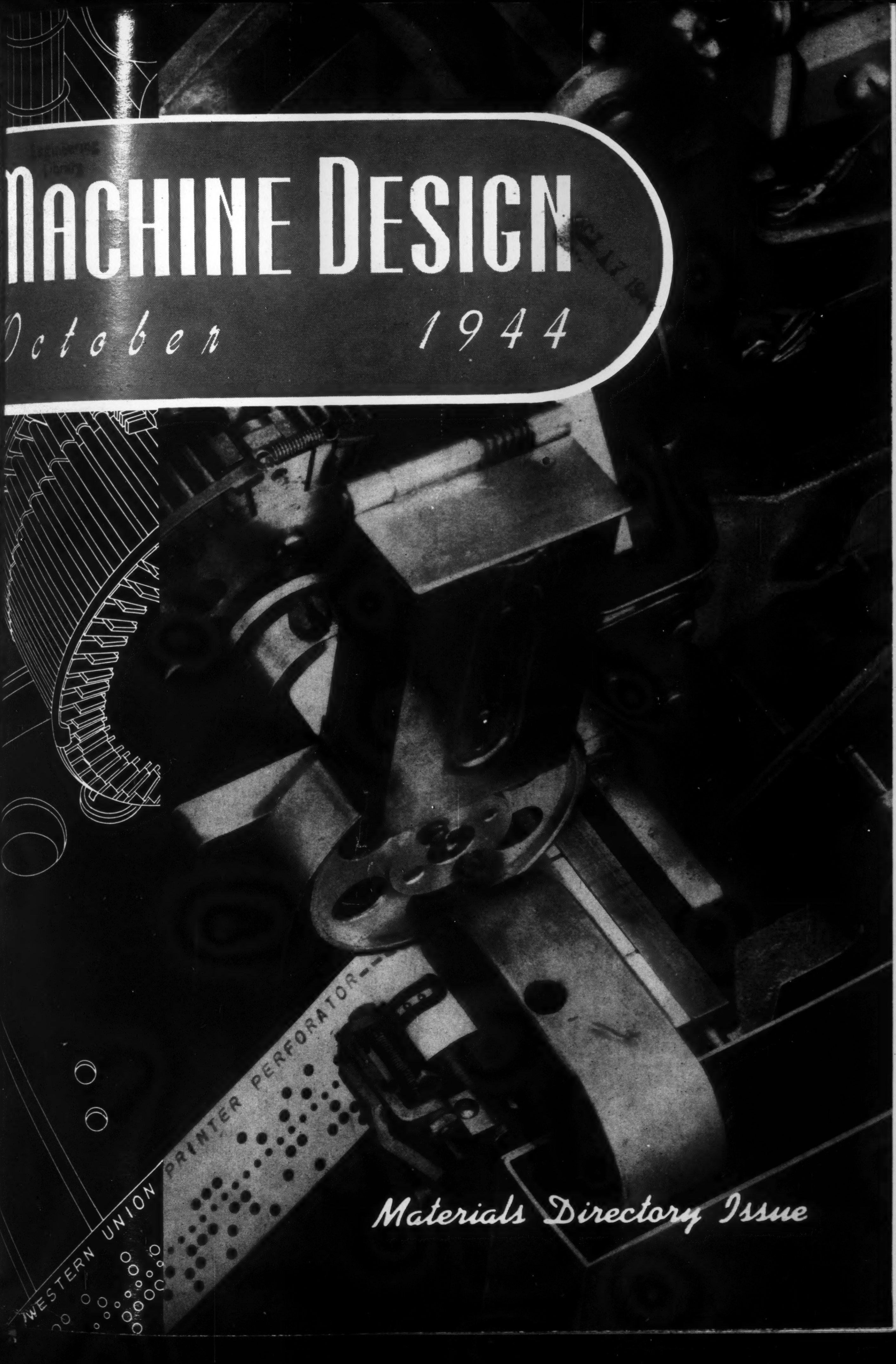
MACHINE DESIGN

October 1944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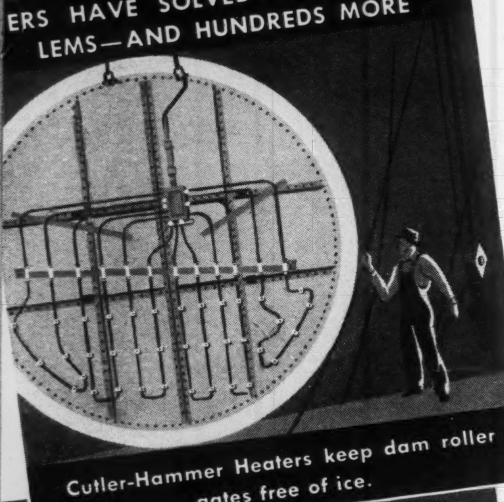
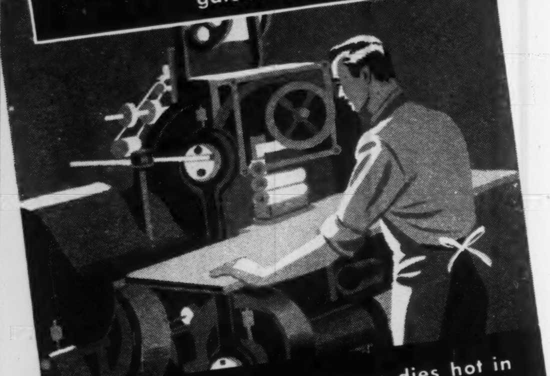
Materials Directory Issue

CUTLER-HAMMER ELECTRIC HEATERS HAVE SOLVED THESE PROBLEMS—AND HUNDREDS MORE

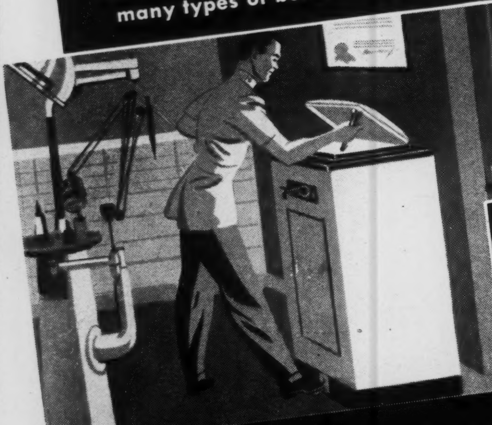


Cutler-Hammer Heaters keep dam roller gates free of ice.



Cutler-Hammer Heaters keep dies hot in embossing presses.

Cutler-Hammer Heater Units are used in many types of better heating devices.



Cutler-Hammer Heaters provide clean, automatically controlled heat for sterilizers.

Here's How

YOU CAN SOLVE THAT SPECIAL HEATING PROBLEM

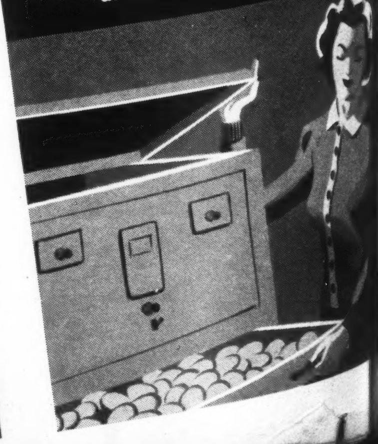
Do you want to heat the cab of a traveling crane . . . or an isolated watchman's hut . . . or a corner in some loft? Do you want to "spot heat" a moving member in a special machine, or a plastic press, or a folding machine, a glue cooker or a shoe stitcher or a warming oven? Do you want heat that you can turn on and off at the touch of a button? Then you will be interested in Cutler-Hammer Electric Heat, tool of a thousand uses, capable of being shaped, applied and controlled in more ways than perhaps you ever thought possible. You may also be interested in the judgment of plant executives and machine designers who know the importance of the correct, efficient and economical solution of such heating problems. They have found that Cutler-Hammer's specialized knowledge in this field, dating from 1910, has been directly instrumental in securing to them the utmost advantages of the electric heating method. Why not write Cutler-Hammer today for details of Cutler-Hammer Electric Heat? CUTLER-HAMMER, Inc., 1310 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

Engineering Excellence Finds its Greatest Reward in the Respect and Confidence of those it Serves

CUTLER-HAMMER
ELECTRIC HEAT
C-H

Cutler-Hammer Heaters simplify thread waxing in shoe stitching machines.

Cutler-Hammer Heaters keep incubators at a safe, even temperature.



MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Contents

OCTOBER, 1944 Volume 16—Number 10

Cover—Printer-Perforator (Courtesy Western Union Telegraph Co.)

Itemized Index 5

This Issue at a Glance 7

Topics 72

Needed—Better Teamwork Between Designer and Metallurgist 75
By Harry W. McQuaid

Scanning the Field for Ideas 79

Centralized Lubrication Insures Bearing Life—Part II 81
By John W. Greve

Unorthodox Plastics Designs Save Parts and Assembly Time 85
By K. T. Barrett

More Bull's-Eyes with New Gun Stabilizer! 91
By C. R. Hanna and L. B. Lynn

Vibration and Noise—Causes and Cures—Part III—Isolation Materials 93
By Colin Carmichael

Specifying Intermediate Components for Machine Drives—Part III—Couplings 97
By Richard K. Lotz

Substitution for Civilian Production Now Confronts Designers! (Editorial) 103

Outstanding Designs 104

Design Roundup 108

Hardness Conversion Tables (Data Sheet) 109

Applications—of Engineering Parts, Materials and Processes 112

Inconel—Wrought and Cast (Materials Work Sheet) 113

New Parts, Materials and Equipment 120

Men of Machines 128

Business Announcements 132

Calendar of Meetings 138

Directory of Materials

- Iron, Steel and Nonferrous Alloys 174
- Index of Alloys by Principal Constituents 200
- New Standard Steel Classifications 202
- Producers of Iron, Steel and Nonferrous Metals 204
- Plastics and Other Nonmetallics 208
- Index of Plastics and Nonmetallics by Type 221
- Producers of Plastics and Other Nonmetallics 222
- Stampings Producers 225
- Forgings Producers 230
- Die Castings Producers 235
- Custom Molders of Plastics 237
- Producers of Machine Finishes 242

Helpful Literature 417

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MAIN OFFICE: The Penton Publishing Co., Penton Building, Cleveland 13.

BRANCH OFFICES: *New York* 17, 16 East 43rd St.; *Chicago* 11, 520 N. Michigan Ave.; *Pittsburgh* 19, Koppers Building; *Detroit* 2, 6560 Cass Ave.; *Washington* 4, National Press Building; *Los Angeles* 4, 130 North New Hampshire Ave.; *London S.W.* 1, 2 Caxton St., Westminster.

PUBLISHED BY The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on seventh of month. Subscription in U.S. and possessions, Canada, Cuba, Mexico, Central and South America: Two years, $10; one year, $6. Single copies, 50 cents. Other countries: Two years, $14; one year, $8.
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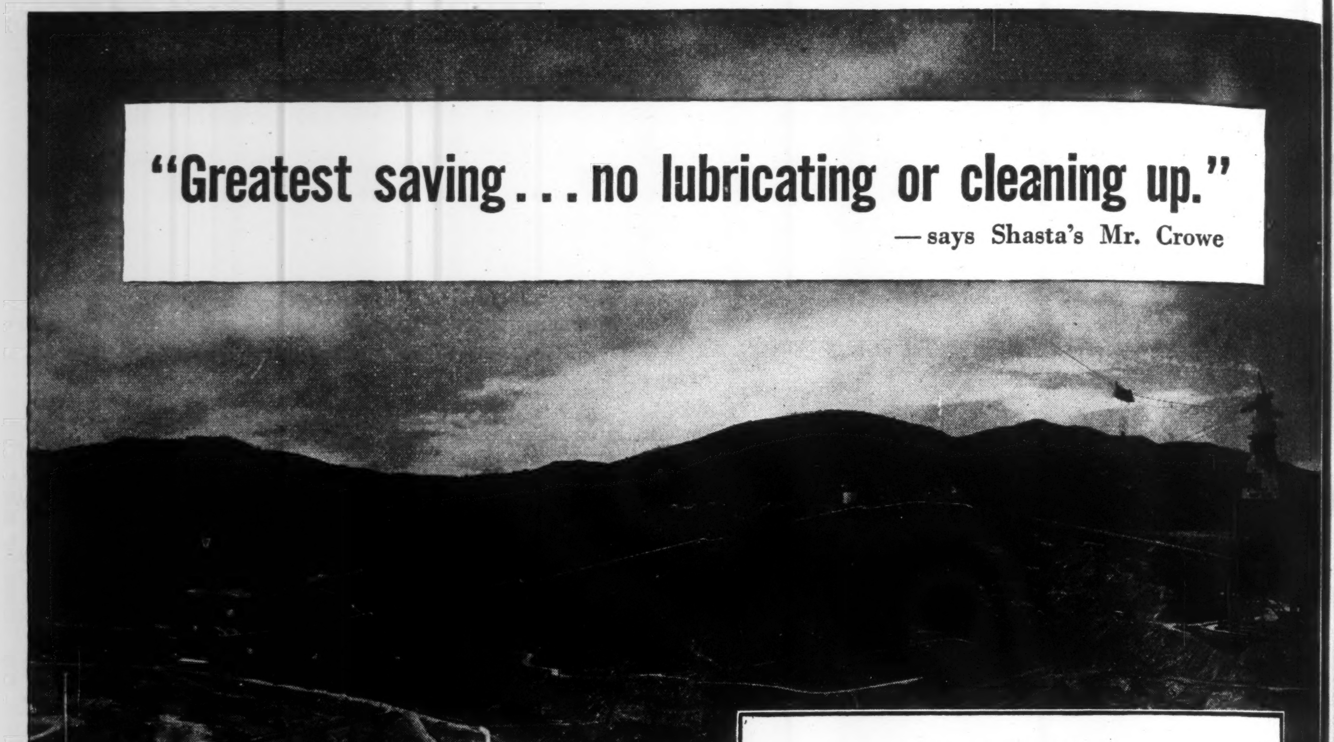
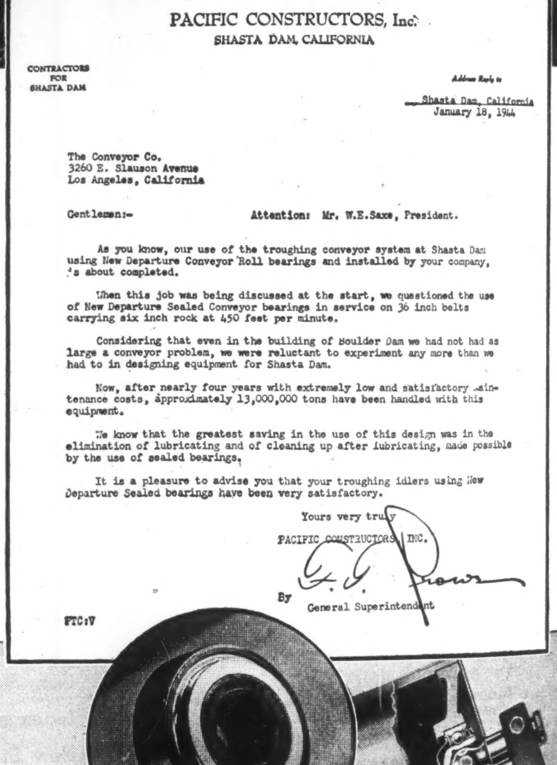
“Greatest saving . . . no lubricating or cleaning up.”

—says Shasta’s Mr. Crowe





PACIFIC CONSTRUCTORS, Inc.
SHASTA DAM, CALIFORNIA

CONTRACTORS
FOR
SHASTA DAM

Address Reply to
Shasta Dam, California
January 18, 1944

The Conveyor Co.
3260 E. Slauson Avenue
Los Angeles, California

Gentlemen:- Attention: Mr. W.E.Saxe, President.

As you know, our use of the troughing conveyor system at Shasta Dam using New Departure Conveyor Roll bearings and installed by your company, is about completed.

When this job was being discussed at the start, we questioned the use of New Departure Sealed Conveyor bearings in service on 36 inch belts carrying six inch rock at 450 feet per minute.

Considering that even in the building of Boulder Dam we had not had as large a conveyor problem, we were reluctant to experiment any more than we had to in designing equipment for Shasta Dam.

Now, after nearly four years with extremely low and satisfactory maintenance costs, approximately 13,000,000 tons have been handled with this equipment.

We know that the greatest saving in the use of this design was in the elimination of lubricating and of cleaning up after lubricating, made possible by the use of sealed bearings.

It is a pleasure to advise you that your troughing idlers using New Departure Sealed bearings have been very satisfactory.

Yours very truly

PACIFIC CONSTRUCTORS, INC.

By F. T. Crowe
General Superintendent

FTC:V

THE last link in the 10-mile Shasta Dam conveying system is a mile and a half unit made by the Conveyor Company of Los Angeles, using 17,500 New Departure Self-Sealed Ball Bearings of two types.

For nearly four years this system has handled 13 million tons of rock as big as 6 inches in diameter.

The satisfactory service obtained is proof that these self-sealed “Lubricated-for-life” ball bearings are not only equal to the job but effect great savings in time and lubricant.

New Departure engineers will be glad to suggest how you may use these ball bearings to your own advantage, when they are again available. Ask for Booklet C.

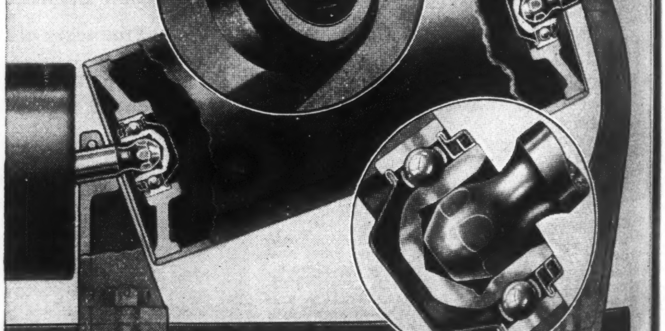
New Departure, Division of General Motors Corporation, Bristol, Connecticut. Los Angeles, Chicago and Detroit.

3281

NEW DEPARTURE

BALL BEARINGS

Nothing Rolls Like a Ball



Bearings are lubricated for life. Shafts and bearings designed to prevent cramping or slippage. Units easily set up.

Itemized Index

Classified for Convenience when Studying Specific Design Problems

Design Problems:

Couplings, specification of, Edit. 97-102
Gun stabilizer scores more bulls'-eyes! Edit. 91, 92, 118
Hardness conversion tables, Edit. 109-111
Lubrication, selecting centralized systems, Edit. 81-84
Plastics assemblies, simplification of, Edit. 85-90
Selecting alloy steels, Edit. 75-78
Vibration and noise—causes and cures, Edit. 93-96

Engineering Department:

Design service, Adv. 26, 28, 41, 60, 317, 324, 381, 406
Equipment and supplies, Adv. 12, 43, 58, 352, 366, 370, 372, 403, 421, 438, 447
Management, Edit. 75-78

Finishes:

Enamels, Adv. 264
Types, characteristics and producers, Edit. 242-246

Materials: (See also Directory of Materials, Page 101)

Aluminum alloys, Adv. 285, 313
Bimetal, Adv. 167
Bronze, Adv. 142, 303
Carbon, Adv. 251
Cork, Edit. 95
Felt, Edit. 93, 94; Adv. 284, 302
Fiber, Adv. 171
Friction materials, Adv. 147
Glass, Adv. 149, 272
Indium, Adv. 312
Insulating, Edit. 122; Adv. 243, 290
Iron alloys, Adv. 308, 315
Magnesium alloys, Adv. 159
Molybdenum, Adv. 154, 170
Nickel alloys, Edit. 113-116; Adv. 163, 250
Plastics, Edit. 85-90; Adv. 151, 152, 161, 254, 262, 263, 265, 266, 289, 311
Powder metal, Adv. 162, 295
Rubber and synthetics, Adv. 145, 155, 252, 274, 304
Solder, Edit. 122
Steel, Edit. 75-78; Adv. 144, 150, 157, 158, 169, 268, 271, 286, 287, 297, 306, 308, 309
Tungsten carbide, Adv. 259
Zinc, Adv. 253

Parts:

Balls, Adv. 396, 401
Bearings, Edit. 79, 108; Adv. 4, 31, 42, 44, 53, 137, 139, 153, 247, 301, 302, 310, 322, 334, 339, 351, 358, 388, 390, 416, 422, BC
Bellows, Adv. 21, 37, 340
Belts, Adv. 337, 342, 397
Belts (conveyor), Adv. 347
Brakes, Adv. 428
Brushes, Adv. 64, 427
Cable controls, Adv. 68, 427
Cams, Adv. 445
Carbon parts, Adv. 275
Cast parts, Edit. 235, 236; Adv. 143, 146, 164, 255, 257, 260, 267, 278, 291, 305, 307, 316
Chains, Edit. 112; Adv. 8, 18, 31, 326, 378, 398
Chucks, Adv. 356, 412
Clutches, Adv. 344, 375, 391, 409, 425, 436
Controls, electrical, Edit. 80, 92, 112, 120, 122, 126; Adv. IFC, 13, 20, 24, 38, 39, 40, 51, 59, 61, 119, 328, 330, 331, 336, 349, 350, 371, 387, 396, 400, 411, 421, 436, 443, 445
Counters, Adv. 395, 449
Couplings, Edit. 97-102; Adv. 10, 134, 377, 424, 428, 432
Electric equipment, Edit. 120; Adv. 65, 70, 341, 370, 406, 407
Engines, Adv. 432, 447
Fabric parts, Adv. 402
Fastenings, Edit. 122, 124; Adv. 1, 6, 14, 48, 127, 129, 318, 335, 338, 370, 371, 386, 392, 394, 412, 414, 426, 439, 441, 443, 445, 450
Filters, Edit. 80, 120; Adv. 22, 27
Fittings, Edit. 124; Adv. 47, 62, 365, 371, 428, 430
Floats, Adv. 375
Forgings, Edit. 230-234; Adv. 156, 261, 283, 306, 308, 314
Gears, Adv. 52, 357, 380, 389, 393, 404, 415, 420, 427, 429, 438, 439, 441, 442
Hydraulic equipment, Edit. 92; Adv. 9, 46, 55, 73, 333, 343, 348, 359, 368, 369, 373, 382, 385, 429, 439
Instruments, Edit. 126; Adv. 374
Joints, Adv. 135, 442
Labels, Adv. 125, 424
Lights, Adv. 437
Lubrication and lubricating equipment, Edit. 79, 80, 81-84, 120; Adv. 25, 319, 375, 396, 405, 436, 443
Machined parts, Adv. 34, 437
Motors, Edit. 108; Adv. 23, 30, 33, 45, 49, 50, 67, 71, 131, 133, 336, 353, 362, 374, 382, 386, 407, 408, 410, 413, 430, BC
Mountings, rubber, Adv. 166, 270, 288
Plastic parts, Edit. 112, 237-241; Adv. 165, 168, 276, 293, 305, 308
Pneumatic equipment, Edit. 80; Adv. 74, 332, 363, 373, 419, 431, 434
Powder metal parts, Adv. 314
Pulleys, sheaves, Adv. 54, 320, 321
Pumps, Edit. 124; Adv. 123, 132, 327, 374, 409, 421, 429, 437, 438, 440, 442
Seals, packing, Edit. 108; Adv. 2, 66, 121, 258, 329, 410, 424
Shafts, flexible, Adv. 409, 433
Shims, Edit. 124
Speed reducers and increasers, Adv. 11, 63, 117, 360, 408, 430
Springs, Adv. 345, 361, 379, 401, 442, 449
Stampings, Edit. 225-229; Adv. 148, 273, 296, 304, 406
Tires, pneumatic, Adv. 138
Transmissions, variable speed, Adv. 367, 407, 430
Tubing, metallic, Adv. 35, 172, 269, 277, 294, 298, 299, 355, 383, 384, 425
Tubing, nonmetallic, Adv. 256, 414
Valves, Adv. 36
Welded parts and equipment, Adv. 16, 17, 248, 249, 292, 300, 354, 423, 433, 434, 447, 449
Wheels, casters, Adv. 422
Wheels, grinding, Adv. 323
Wire (electrical), Adv. 15

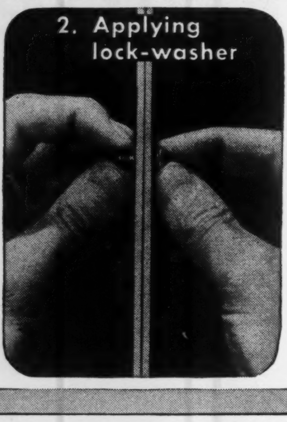
Production:

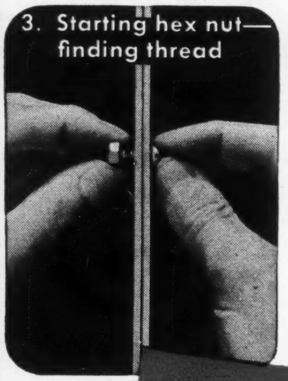
Grinding, Adv. 399
Hardening, Adv. 19, 36, 56, 57
Service facilities, Adv. 29
Tools, Adv. 32, 325, 420, 425, 432, 440

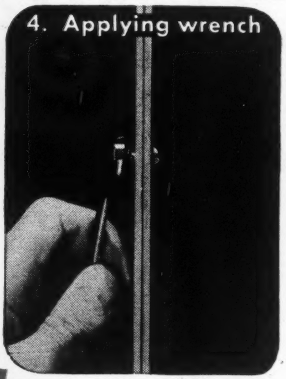
MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally.

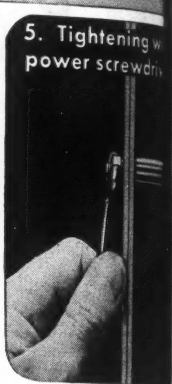
Which is Better?

1. Starting screw

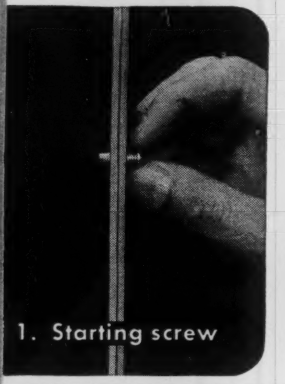

2. Applying lock-washer

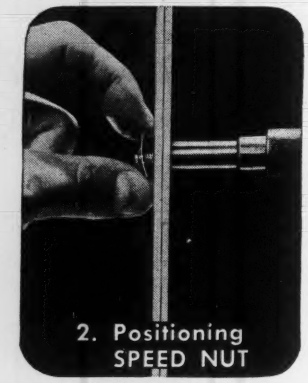

3. Starting hex nut—finding thread

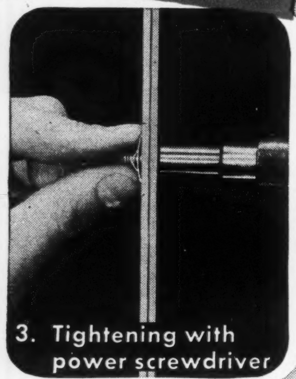

4. Applying wrench


5. Tightening w
power screwdriv

THE OLD WAY WITH 5 HAND OPERATIONS


1. Starting screw


2. Positioning SPEED NUT


3. Tightening with power screwdriver

OR THE SPEED NUT WAY WITH ONLY 3 OPERATIONS

And **a SPEED NUT is a self-locking nut, too, that weighs less, stops vibration loosening and cuts assembly costs 40-50% . . .**

The SPEED NUT method requires only 3 hand operations as shown in photos above. And only 2 parts are needed instead of 3. Why go through 5 hand operations when only 3 are necessary? Why handle 3 parts when only 2 are required? For an eye opener on the economies of the SPEED NUT system just multiply this 40% motion-saving by the millions of fasteners you use per month. Then add to that the saving by eliminating 1/3 of the parts. Your figures will amaze you. The winning products in postwar competition will be those that are assembled faster and protected against loosening from vibration. Billions of SPEED NUTS were used before the war and on war products, too. More billions will be used on postwar products. Over 2,000 shapes and sizes. Engineers who move up faster are those who know how to make assembly lines move faster. Write for literature.

TINNERMAN PRODUCTS, INC.
2085 FULTON ROAD, CLEVELAND 13, OHIO
In Canada: Wallace Barnes Co., Ltd., Hamilton, Ontario
In England: Simmonds Aerocessories, Ltd., London

FASTEST THINGS IN FASTENINGS

See our display at the National Metal Congress, Space No. I-617

Speed Nuts*
[PATENTED]

*Trademark Reg. U. S. Patent Office

This issue at a glance

Better Teamwork Between Designer and Metallurgist . . . .

. . . . will be needed in the development of machines of the future. Strength of machine parts is neither all in materials nor all in design. It's a combination of both. What designers and metallurgists should know to facilitate closer collaboration is the subject of the thought-provoking discussion beginning on Page 75.

Unorthodox Plastics Designs . . . .

. . . . employing "molded-in" constructions can save parts and assembly time. You'll want to see and read about the camera which "snap-lock assembles" without auxiliary fasteners! Also the plastic case with "pushed-in" hinges. Here's an article which may save you dollars and cents on your future plastic assemblies. See Page 85.

Stabilizer on Tank Guns . . . .

. . . . gives our tank men a distinct edge over the Hun and Jap. It permits accurate fire while tank rolls over rough terrain. How does it work? Turn to Page 91 for the engineering facts behind this amazing new achievement of American research.

Any Machine's Life Depends Largely . . . .

. . . . on the performance of its bearings. In turn, bearing life is dependent on lubrication. How bearing lubrication is effected by various mechanical and "restricted orifice" types of centralized systems is discussed in the timely article beginning on Page 81.

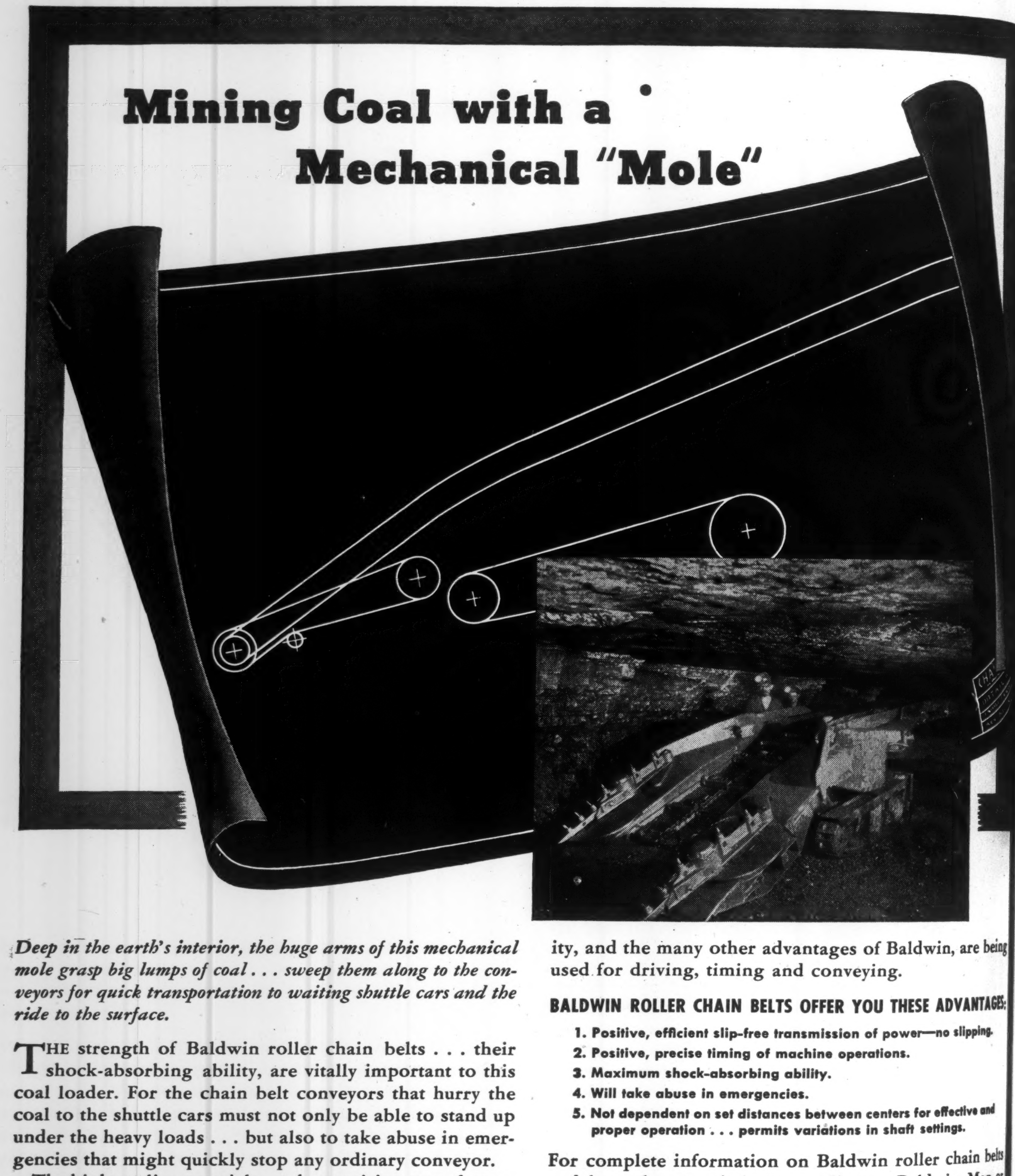
Absorption and Isolation of Vibration . . . .

. . . . is a study of paramount importance to all engineers responsible for design. A number of isolation materials are available, but how to use them for specific applications? Quite likely you'll find the answer in the article commencing on Page 93.

Engineering Materials, New and Improved . . . .

. . . . as well as the familiar standbys, are destined to play significant roles in designs of the future. What materials are available? From whom? What are their key properties and characteristics? Get the facts from MACHINE DESIGN'S "Directory of Materials", Page 141.

Mining Coal with a Mechanical "Mole"



Deep in the earth's interior, the huge arms of this mechanical mole grasp big lumps of coal . . . sweep them along to the conveyors for quick transportation to waiting shuttle cars and the ride to the surface.

THE strength of Baldwin roller chain belts . . . their shock-absorbing ability, are vitally important to this coal loader. For the chain belt conveyors that hurry the coal to the shuttle cars must not only be able to stand up under the heavy loads . . . but also to take abuse in emergencies that might quickly stop any ordinary conveyor.

The high quality materials . . . the precision manufacture . . . the years of experience . . . and, above all, the superior design of Baldwin roller chain belts are responsible for their ability to resist wear. Throughout industry this ability, and the many other advantages of Baldwin, are being used for driving, timing and conveying.

BALDWIN ROLLER CHAIN BELTS OFFER YOU THESE ADVANTAGES:

1. **Positive, efficient slip-free transmission of power—no slipping.**
2. **Positive, precise timing of machine operations.**
3. **Maximum shock-absorbing ability.**
4. **Will take abuse in emergencies.**
5. **Not dependent on set distances between centers for effective and proper operation . . . permits variations in shaft settings.**

For complete information on Baldwin roller chain belts and how they can help you, call your Baldwin Man or write for your copy of catalog M. Baldwin-Duckworth Division of Chain Belt Company, 321 Plainfield Street, Springfield 2, Mass.

FOR BETTER DRIVES...

BALDWIN

ROLLER CHAIN BELTS

TOUGH CUSTOMER

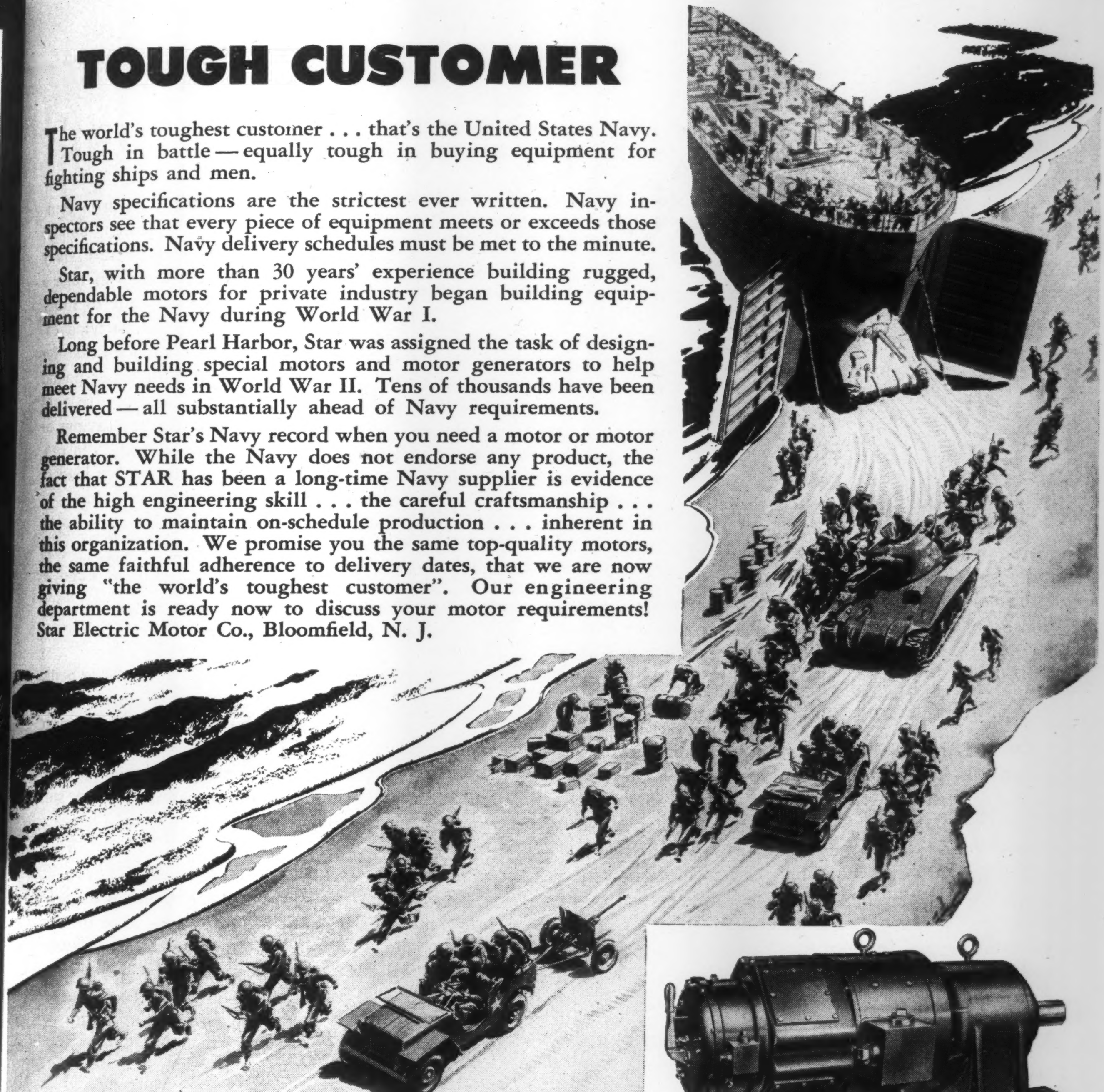
The world's toughest customer . . . that's the United States Navy. Tough in battle — equally tough in buying equipment for fighting ships and men.

Navy specifications are the strictest ever written. Navy inspectors see that every piece of equipment meets or exceeds those specifications. Navy delivery schedules must be met to the minute.

Star, with more than 30 years' experience building rugged, dependable motors for private industry began building equipment for the Navy during World War I.

Long before Pearl Harbor, Star was assigned the task of designing and building special motors and motor generators to help meet Navy needs in World War II. Tens of thousands have been delivered — all substantially ahead of Navy requirements.

Remember Star's Navy record when you need a motor or motor generator. While the Navy does not endorse any product, the fact that STAR has been a long-time Navy supplier is evidence of the high engineering skill . . . the careful craftsmanship . . . the ability to maintain on-schedule production . . . inherent in this organization. We promise you the same top-quality motors, the same faithful adherence to delivery dates, that we are now giving "the world's toughest customer". Our engineering department is ready now to discuss your motor requirements! Star Electric Motor Co., Bloomfield, N. J.



NOW . . . what's your motor problem?

This Warsaw Elevator motor that lifts and lowers tanks and trucks between top deck and tank deck of an LST is designed to meet Navy demand for compactness, power and ability to stand shocks of shell fire, bombs and mines.

This unit is typical of Star's work for the Navy — and Star's ability to handle any post-war motor problem that may confront you. Star's standard motors — from 1/20th to 200 H.P. will probably satisfy your requirements. But when your specifications call for a "special" to fit mechanical "tight spots", you can enlist Star's know-how in motor design, plus Star's unique welding process, to great advantage.

STAR MOTORS

POWER PACKAGED AS YOU NEED IT

Topics

FIRST LARGE-SCALE, concerted move to provide domestic and international airways with sky giants in the immediate postwar period involves an order for 93 high-speed Douglas air liners from three airlines. The contracts placed by American Airlines, Pan American-Grace and United Airlines calls for 40 DC-4's and 53 DC-6's, costing in excess of $50,000,000.

OUTSTANDING property of fluid silicones, organosilicon polymers, is their exceptionally low rate of viscosity change with temperature. Manufactured in viscosities ranging from water-thin to highly viscous, certain types remain usable as liquids between −110 and 500 degrees Fahr. Other silicones have been developed by Dow Corning Corp. for wartime applications, these being electrical varnishes and insulating resins for electrical equipment operating at high temperatures.

WARTIME USE of alternative steels is enabling the United States to outproduce the world, according to H. B. Knowlton, International Harvester Co. National Emergency steels have demonstrated that a much larger number of low-alloy steels than was supposed possible is giving satisfactory service and is putting emphasis on selecting steels by physicals rather than chemicals.

JET PROPULSION turbines work as well in the substratosphere as they do where the air is not so "thin". With less air resistance to the plane the jet does not have to push as hard. According to H. A. Winne of General Electric, the jet "doesn't push against anything that it doesn't provide itself".

DESIGN CHANGES which reduce manufacturing costs but add weight to aircraft should be carefully considered. According to weight engineers of the Glenn L. Martin company a heavy design, though inexpensive to manufacture, may be more costly in the long run than a lightweight design more difficult to fabricate, because of reduced pay-load carrying capacity of a plane. Exhaustive analyses place values for weight reduction between $32 and $600 per pound per ship. However, on a conservative basis of $17.25 per pound saved, evaluation of the savings of a recent change showed that although $2.75 in production cost was saved per ship, disposable load of 3.2 pounds lost was valued at $55.20 per ship.

IN A SINGLE telephone cable only as large as a man's wrist go 3,636 wires.

STORAGE-BATTERY operated welders are being utilized for spot welding of structural aluminum up to 3/16-inch thickness. Developed by Progressive Welder Co., the method also may be applied to seam welding at high speeds. The welder wheel is internally refrigerated, requiring no external water supply, and has a replaceable rim for renewal.

EXTRUDED TUBES of Tenite, dyed by a special process, form sleeves over fluorescent lamps to make "black light" sources. These tubes activate fluorescent-treated dials and knobs on aircraft panels at a fraction of the cost of other black light sources and without the heat commonly associated with such units.

TREAD DESIGN for truck tires of synthetic rubber has been developed by Goodyear, retarding the growth of tread cracks and reducing running temperatures of the tires by as much as 50 degrees. Retarding of crack growths is accomplished by altering the conventional, continuous tread ribs to include terminals at approximately every half inch in the crevice between the ribs. Ventilated shoulder on each tire effectively reduces the heat generated.

INTEREST IN ELECTRONICS and their applications in industry has caused the Westinghouse Co. to make its courses, designed for instructing its own employes, available to any group wishing to give the course. In ten-parts, each requiring two hours, the course utilizes slide films, lesson books, quiz books and an instructor's manual.

MACHINE DESIGN

Needed
Better Teamwork Between Designer and Metallurgist

By Harry W. McQuaid
Republic Steel Corporation

IT IS in the field of strength of materials that the paths of the modern metallurgist and machine designer become thoroughly entwined and the exact province of each is difficult to define. The field covered by steel metallurgy has enlarged since before the first World War when the metallurgist was, by definition, interested only in the extraction of metals from their ores.

Today, broadly speaking, we have: The steel mill metallurgist, who is primarily concerned with the production and processing of steel in bar, sheet or casting form; the shop metallurgist, concerned with the conversion of raw steel to the final form prescribed by the machine designer; and the supervisory metallurgist who, in charge of laboratories of both routine and experimental type, concerns himself with the selection of steel and its treatment to meet conditions under which a given machine part must operate.

It is the supervisory metallurgist to whom a machine part which has

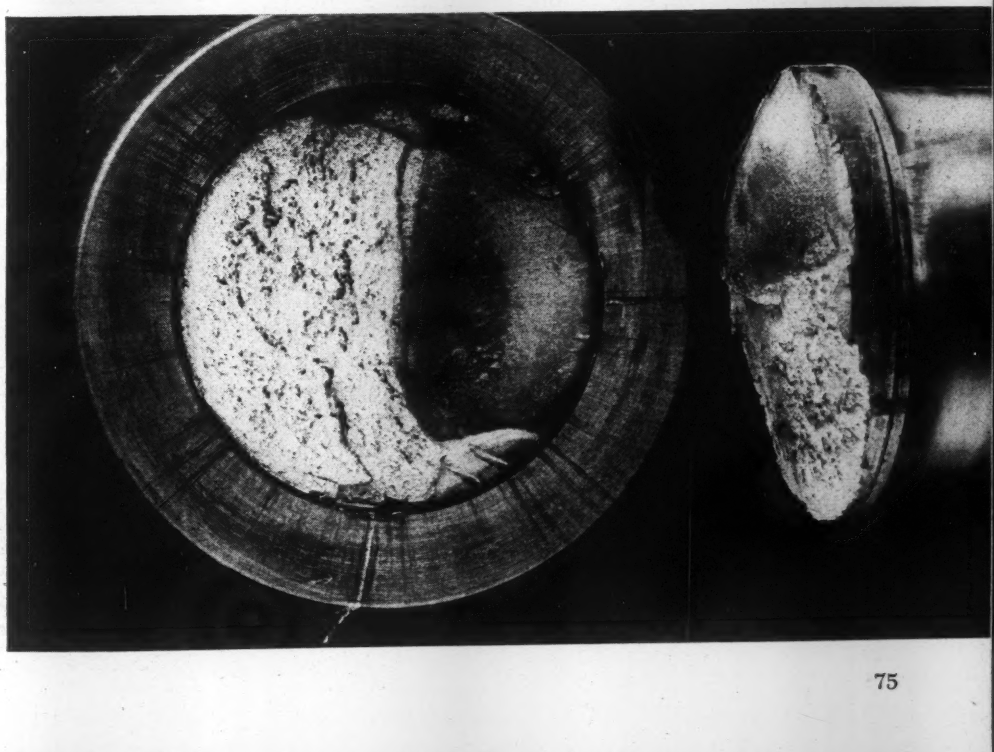


Fig. 1—Failure of railway car axle in laboratory test due to stress localization at edge of wheel hub (Photo by courtesy of A. A. R.)

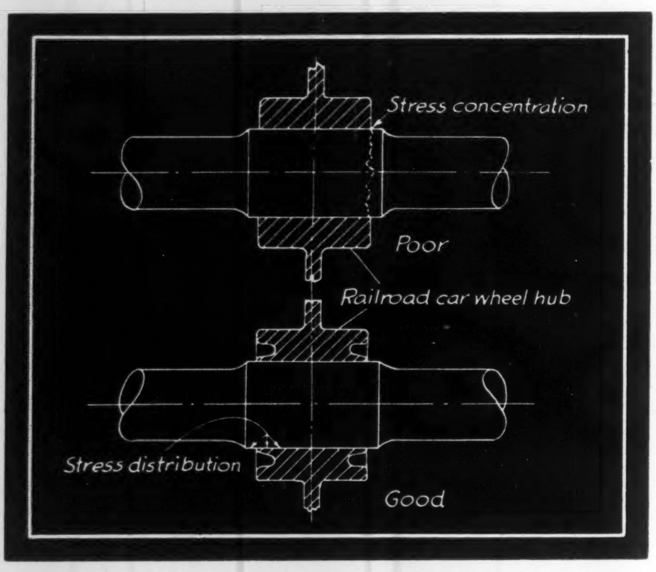


Fig. 2—Stress concentration which existed in shaft shown in Fig. 1 is indicated in top view. Bottom view shows how stress can be distributed over greater area of shaft

failed usually is taken and who is asked to explain the failure and recommend action to prevent further trouble. Where the failure is serious, and especially if it affects greatly the sales of the machine, he is told to go to almost any extreme in order to eliminate it. Too often, however, he is asked to take stringent measures with the expectation that he will suggest only changes in material or heat treatment and not changes in actual design.

A Matter of Dollars and Cents

While it is true that many times the metallurgist can prevent future failures of a part through recommendation of higher alloy steel or special heat treatments, it should be recognized that both of these measures generally involve higher initial and processing costs. How much better it would be if the part could be made at an absolute minimum of cost through the use of less expensive low-alloy steel, requiring only routine heat treatment! But can this be done?

The answer is, in a great many instances, "yes"—providing the designer and metallurgist will get together, determine what is actually involved in the part failure, and proceed to take corrective measures regardless of who was responsible for the original failure. But they cannot do this unless they speak a common language. In other words each should know enough of at least the basic principles involved in the other's job to enable him to understand to what extent design and metallurgy can collaborate to make the part as good as requirements demand. There is a lot about design that metallurgists should learn and a lot about metallurgy the designer could put to good use.

What then are these things which both should realize more fully if they are to work together more closely in the future? First, we will have to stop putting the cart before the horse. The time for the metallurgist and designer to get together in full collaboration is at the outset—during the intial stages of design—not after a part has failed in service. Left to himself, the design engineer has a tendency to reach a too-hasty conclusion in selecting a steel on the basis of data obtainable from handbooks developed primarily to advance a particular type of alloy, or he sticks to a grade of steel in use for many years and which may be more expensive than conditions warrant.

This obviously is poor practice. It is the metallurgist who has the greatest fund of knowledge about the technicalities involved in selecting steels. He should be supplied with all of the available factors on loading, permissible costs, corrosion resistance required, wearing properties desired, etc., and asked for recommendations regarding not only the material but the soundness of the design.

Both designers and metallurgists should appreciate that a prime consideration in the selection of a steel and its heat treatment for any machine part is to aim at the lowest possible cost compatible with meeting fully the requirements of the application. This isn't always easy, because no matter how well designed and constructed a machine might be, there always are careless users who soon will have it down for repairs. On the other hand it is not good engineering to make a part a great deal better than it need be. A balance must be struck. In this connection, every designer and metallurgist should be interested in the fatigue curve of a given part under service condi-

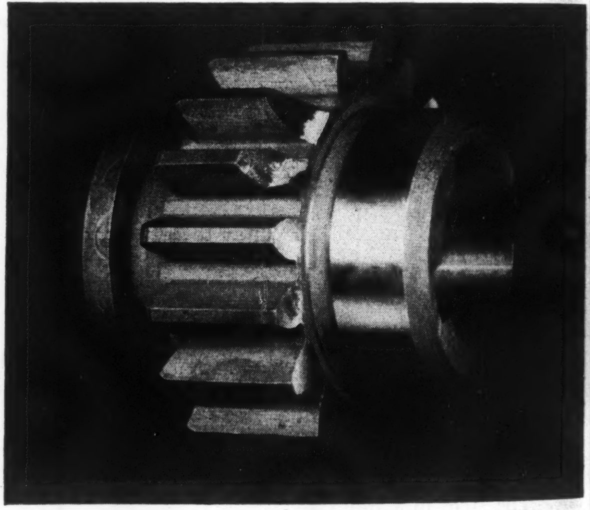
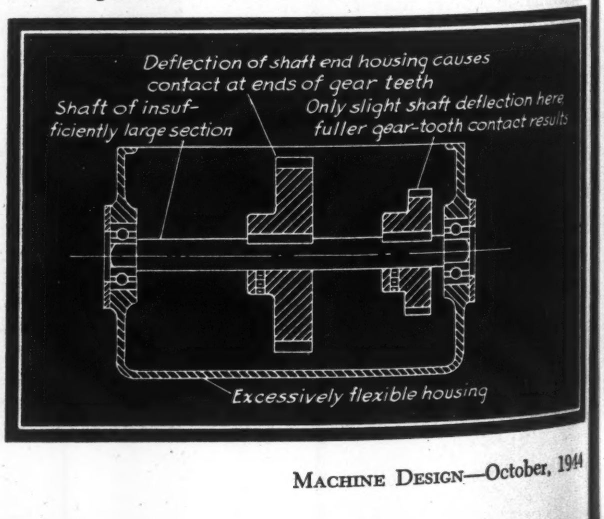


Fig. 3—Above—Shaft on which this gear was fastened deflected under load. Contact therefore was limited to the ends of the teeth with the failure shown resulting

Fig. 4—Below—Increasing the shaft diameter, stiffening the housing with ribs and bringing the shaft bearings closer together would make this a stronger gearing unit


Deflection of shaft end housing causes contact at ends of gear teeth
Shaft of insufficiently large section
Only slight shaft deflection here fuller gear-tooth contact results
Excessively flexible housing

tions and be able to develop the part so that it's operating life is not too far out on the curve.

Even so, the stresses to which a machine part is subjected in the final assembled machine may be different in intensity and type than one might be led to expect. Frequently a part which seems perfectly satisfactory in every test, as a part, will fail quickly when tested in the assembly. Yes, there is much yet to be learned about stress analysis. However, assimilation of the vast amount of existent information on the subject will go far toward helping to make more accurate predictions of the true nature of part stressing. Some of the most elementary rules for the elimination of stress concentrations in machine parts are flagrantly disregarded even today in spite of the fact that they have been emphasized and re-emphasized in the past. Such things as are pointed out by the drawings and photographs of *Figs.* 1 to 7 should be heeded seriously when developing the design of all kinds of machine members.

Again, metallurgists and machine designers of the future will have to become more thoroughly acquainted with the true nature of stresses set up in mechanisms wherein life is purposely limited to within a predetermined range. It is my opinion that many designers—and metallurgists as well—are of the "static" type. That is, their designs and calculations are based upon formulations which are primarily of the equilibrium type and they often are confused when it comes to interpreting *dynamic* loading.

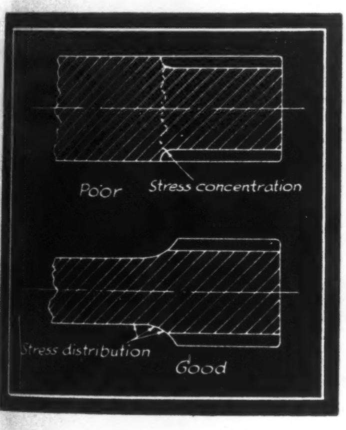
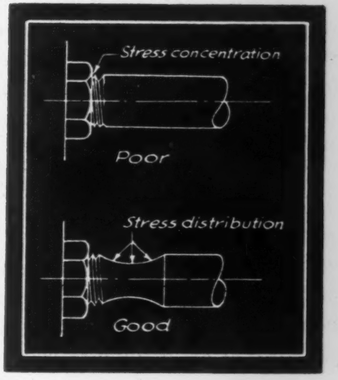


Fig. 5—Left—Examples of good and poor designs of shaft splines

Thus their training should emphasize more than it has in the past a thorough study of dynamics and deflection phenomena. In order to do this competently, full knowledge of the stresses inherent in any given part due to heat treatment or other processing will be required. A good start toward this end has been made by Almen*, in addition to whose work, however, a great deal yet remains to be done, particularly in evaluating the stresses set up in machine parts due to temperature changes, deflection and inherent internal stresses.

Surprisingly enough, the great amount of work which has been carried out in evaluating the effects of inherent internal stresses on the performance of machine parts, and the relationship which exists between them and hardenability is only now becoming common metallurgical and design knowledge. Here again, as well as in the determination of the effects of compression and tension stresses on fatigue life, the work of Almen has contributed greatly in directing our thinking to more sensible and constructive channels. This work has proved that there is a direct relationship between the hardenability of heat-treated parts and the internal stresses which subtract from or add to the operating stresses. This increase or decrease of the operating stresses by internal stresses set up in heat treatment probably is the most important single factor in determining the success or failure of a highly stressed heat-treated steel part.

Fig. 6—Right—Notch effect such as exists in upper view can be eliminated and stress distributed by proper design such as below



It is the study of these most important stresses that brings up the question of whose domain is most directly concerned. In the past the question of internal stressing set up by heat treatment always has been a responsibility of the metallurgist, particularly with regard to failures in the heat-treating operation which show up as losses due to cracking or severe distortion. Not too much thought has been given to the control of these stresses which cause distortion and sometimes cracking *during the life* of the finished part. Thus, if the metallurgist is to be responsible for the performance of a part, it is he who must control such stresses and be the responsible party in their elimination or control. On the other hand, the design engineer must be fully acquainted with the extent and location of stresses set up in processing if he is to design intelligently.

Keep Up to Date on Stress Analysis

Both the metallurgist and the design engineer should have the means and the understanding necessary to evaluate internal stresses which are incidental to the selection of a given analysis of steel and its heat treatment, and also know how these stresses are affected by the design. Further, both the metallurgist and the engineer must be thoroughly acquainted with the latest developments in stress analyses and the means for determining what stresses will exist in a given design due to processing and operating. Many metallurgists and designers are but little acquainted with the most recently developed methods employed in stress analyses and they, therefore, should pay close attention to this field if designs of maximum performance with minimum materials are to be developed.

Very sensitive strain gages have been devised which indicate local strain under various conditions of loading. These have been helpful in determining the effects of loading on parts of nonsymmetrical shape. Calibrated lacquers have been developed which indicate, by cracking of the coating, the stresses set up at the surface under a given loading. Sensitive extensometers also are available which

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*J. Almen—*S.A.E. Transac.*, Vols. 50, Feb. 1942; 51, July, 1943.

indicate the movement occurring in loaded parts. Much work has been done in the development of photoelastic studies whereby models of plastic are produced, subjected to stresses comparable to those encountered in service, and illuminated by transmitted polarized light. Areas of high stress concentration are thus clearly indicated.

In spite of all the work which has been done in estimating stresses under loading we still are very much in the dark as to stresses incidental to heat treating and cold working and, since in many cases these stresses are much greater than those applied in service, their determination becomes of the utmost importance. Recent research has shown how high some of these stresses can be and has indicated means of converting tension stresses which decrease load-carrying capacity to compression stresses which increase load carrying capacity. Every machine designer as well as every metallurgist who is responsible for performance should be thoroughly familiar with the means available for introducing compression or tension stresses at a given point where they are necessary to avoid failure.

Since, as has been indicated, these internal stresses are closely related to depth of hardening as well as the degree of hardening, no serious study can be made of this subject without a full knowledge of the effects of various steel analyses, heat-treating procedures, methods, etc., on the stresses set up at any point in an important heat-treated part. A gear tooth is a good example of this, since under ideal conditions two gear teeth transmitting a load from one to another should normally be designed so that if failure does occur it is due to uniform pitting at the pitch line. The pitch line should be an area of full-load rolling contact with high compression stresses at the surface and correspondingly high tension stresses below the surface. The object then is to reduce the compression stresses at the surface to a minimum under no-load conditions, otherwise the tendency to fail in tension at some point below the surface is aggravated. For this reason care should be exercised not to introduce any unnecessary compression stresses at the pitch line. On the other hand, if the beam strength of the tooth is low and failure occurs by a fatigue crack at the root of the tooth, then steps should be taken to introduce compression stresses at this portion of the tooth. This might be done by means of localized shot-blasting.

Importance of Hooke's Law

Thus, in the field of stress analysis both the metallurgist and the designer have mutual responsibility. Many times the metallurgist has been criticized for his work when the primary factor in the failure was the engineer's reluctance to recognize the importance of Hooke's Law or the relatively constant value of the modulus of elasticity of steel. Many times a few ribs on a gearcase or a heavier beam section in a supporting member (see *Fig.* 4) or the shortening of the distance between supporting bearings will do far more toward improving performance of a gearbox than all the efforts of the entire metallurgical profession.

An example of the overlapping realms of the metallurgist and machine designer is the case of automotive transmissions, where for years it apparently was the metallurgist who assumed full responsibility for the performance of treated gears. The metallurgist was hard pressed to prevent pitting, fatiguing at the root of the tooth, or failure at the end of the gear (*Fig.* 3), and much effort was spent developing special steels and treatments which would produce gears to meet the expectations of the designer and the users. In spite of all the efforts of the metallurgical fraternity it was difficult to provide any startling improvement, although steady progress was made. In 1939, however, one large motor company, by carefully applying what seemed to be common sense rules of design, was able to cut the weight of the transmission from 150 to 75 pounds and at the same time increase the life of the low-speed gears under full engine torque from 2½ hours to approximately 40 hours. At the same time a great improvement was made in the second gear performance by eliminating fracture at the sharp forward edge of the helical teeth on the countershaft. All these results were obtained by the simple process of eliminating the factors which contributed to distortion. The changes made consisted of substituting a stiff-ribbed cast iron cover for a light pressed steel cover, and the dividing of the long tooth of the combined low and reverse countershaft gear into two parts. Also, teeth which were failing because of the sharp acute angle due to the helix, were increased in length and then beveled starting from the same gear tooth width as before. A close study of these changes indicates clearly that before the metallurgist is brought in and asked to prescribe some steel or treatment which will save a transmission, or other part, every attempt should be made to eliminate stress concentrations of all types, and in most loaded parts this is tied up with deflection and poor contact.

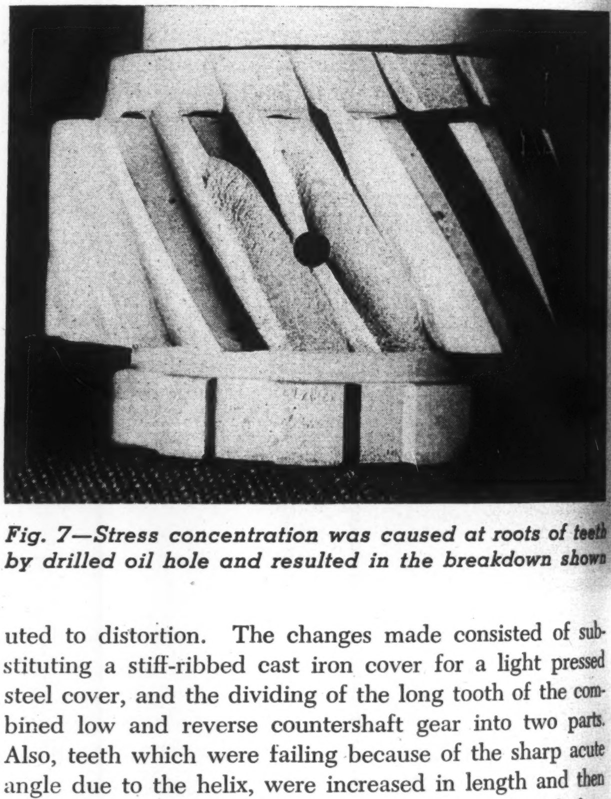
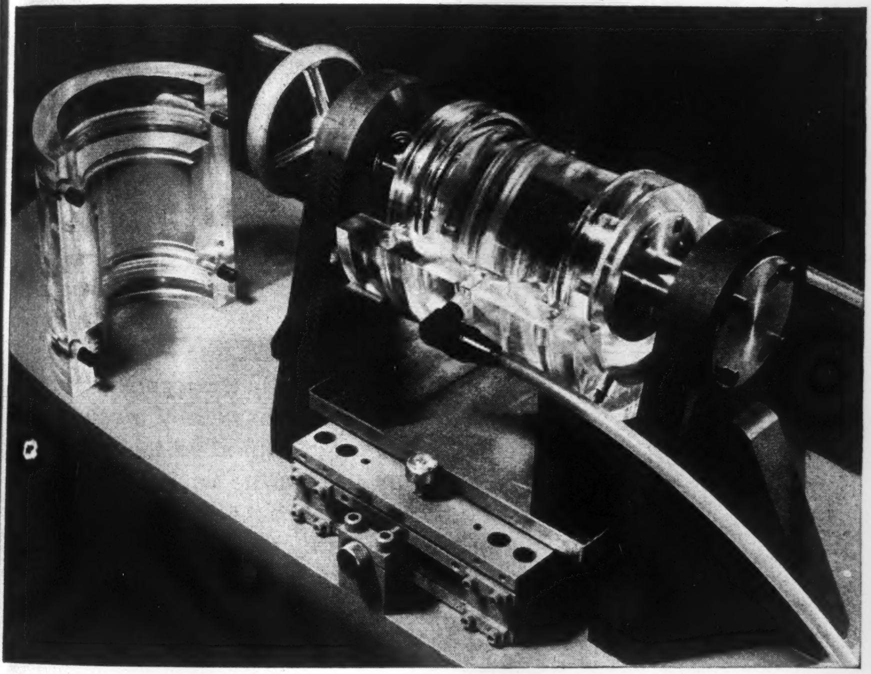


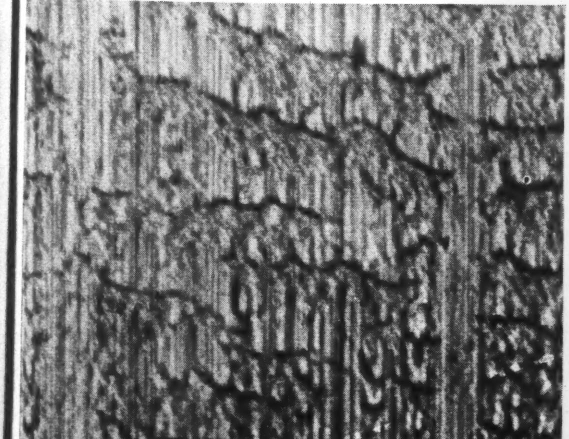
Fig. 7—Stress concentration was caused at roots of teeth by drilled oil hole and resulted in the breakdown shown

It is obvious that the realm of the metallurgist has been greatly broadened in the past years, especially in manufacturing plants which are not large enough to maintain an individual specialist in charge of each operation. The supervision of many special operations and the responsibility for the quality of the work has gravitated into the province of the supervisory metallurgist. The design engineer is equally interested in all these fields because they reflect in the performance of his designs. It is only by the wholehearted cooperation of the two types of engineers that either can be completely successful.

Scanning the Field for Ideas

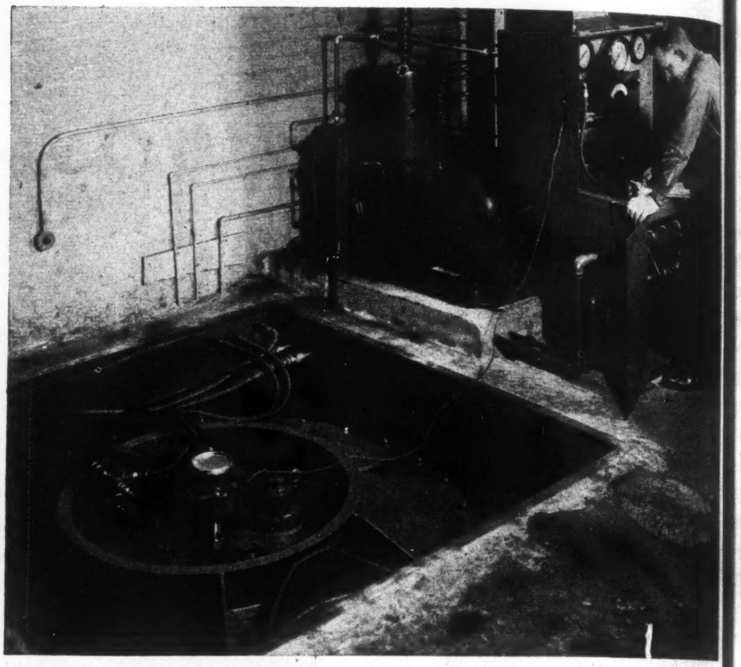


Flow of lubricant through a bearing is being investigated with the aid of a transparent model, left, at the Westinghouse Research laboratories. Many practical problems in oil flow still exist although the classical equations governing the performance of film-lubricated bearings were formulated more than fifty years ago. The bearing is a half-size model of a 7 by 7-inch prototype constructed so that it may be operated by hand or motor. Oil is supplied by a circulating pump as in the prototype. By tinting the oil red the flow through the bearing may be readily observed, revealing at a glance whether the seals are working properly, whether the oil passages are handling the lubricant as intended and whether the reliefs are correctly located.



Surface replicas for inspection, comparison and record are being made on a clear plastic film by dissolving one side of the film and pressing it into the surface of the material being studied. The three-dimensional replicas thus produced may be projected with an ordinary slide projector, giving details of irregularities of .0001-inch at 100 diameters magnification. Such an enlargement is illustrated at left for a 64 root-mean-square, microinch machined surface. Developed by R. D. McDill laboratory, the film causes a variation in the amount of light transmission when projected. The thicker portions of the film project shadows, varying in intensity as the thickness. The possibilities of estimating the depth of the valleys with a calibrated lens and of comparing surfaces with a standard appear promising, particularly because of the simplicity of the method.

Vacuum test pit illustrated at right is utilized to study stresses and improve quality of high-speed rotating machinery at the research laboratory of Buffalo Forge Co. Of heavy reinforced construction, the 6-foot diameter shell is designed to withstand absolute vacuum. The pressure in the vessel may be reduced to as low as 200 microns of vacuum (.00787-inch mercury absolute). Impeller or part to be tested is suspended from the shaft of a small air turbine mounted on the cover of the pit. Power to drive the fan, exclusive of the turbine friction, is .00025 of the power needed to drive it under normal conditions. In order to keep the speed-indicating device from absorbing power an electronic indicator is used.

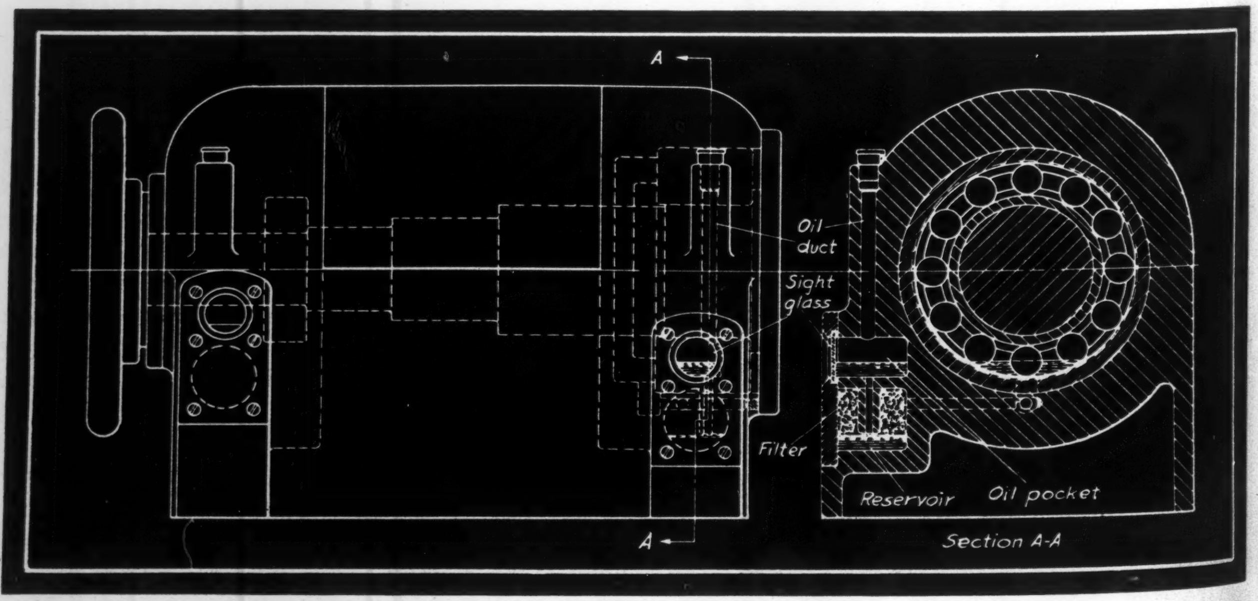


On new design the impeller may be tested to destruction in determining the weakest section or some unpredictable condition. For this purpose a laminated shield is placed within the main shell so that the force caused by rupture will spend itself against the shield. A glass aperture in the cover of the pit permits study with stroboscopic light. Also, through the use of strain gages in circuit with a cathode ray oscilloscope, stresses and vibration may be visualized and measured.

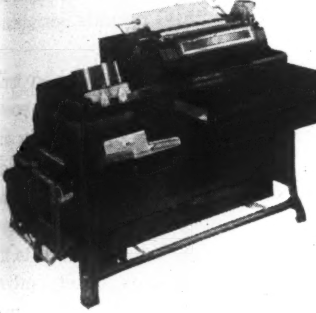
Filtered lubrication for the ball bearing design illustrated in the drawing below is particularly adapted to hand oiling systems where a machine operates with an abrasive. Drilled in the bearing housing or machine head this lubricator, developed of Bausch & Lomb Optical Co., has attractive appearance and smooth outlines.

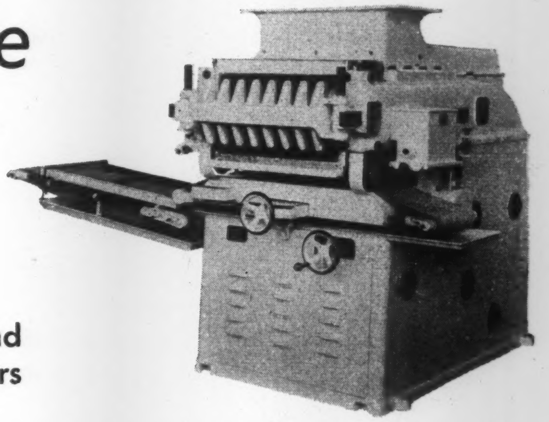
Head is drilled to provide vertical oil duct as shown leading into a pocket drilled from the front of the housing. Another duct is drilled to a reservoir which is also connected with the bearing. A screen in the reservoir provides sump above which is a mass of wool or other filtering material. Secured to the side of the head by screws is a plate which serves as the outside wall of the pocket and reservoir, and incorporates a sight glass to indicate the oil level in the bearing.

System is of sufficient size to provide an abundant supply of oil without the use of large external fittings. Level of oil in the sight glass will always be the same as that in the bearing. Inside of pocket is painted white to assure clean oil and to facilitate reading of level.



Centralized Lubrication Insures Bearing Life





By John W. Greve

Part II — Mechanical and Restricted Orifice Lubricators

BECAUSE the effectiveness of a centralized lubrication system depends upon the skill with which it is applied to a machine, and because no system is better than the dependability and accuracy with which the lubricant is metered to each bearing in accordance with its particular requirements, this series of articles presents the basic considerations in selecting such a system. The metering valves, being the critical key to satisfactory performance, are discussed according to the three principal types—piston displacement, mechanical or box oilers and restricted orifice. The first group was discussed in Part I. Also determination of the quantity of lubricant required was treated. The second and third groups will be the subject of this article.

Mechanical or box oilers are for many applications the most satisfactory system. Generally the system comprises a central reservoir with individual pump units or a multiple-pump unit with individual lines to each bearing. Often referred to as semi-centralized systems because individual pumps are used for each bearing, mechanical oilers are usually connected direct to a power take-off either rotary or reciprocating. Individual rates of feed to each bearing are adjustable at the pump. Because of the possible length of individual lines, systems of this type are located as close to the bearings as possible and are best adapted to machines having closely grouped lubrication points. Where a large number of remote bearings is encountered, one of the other systems is preferable.

In *Fig.* 1 is shown a trimmer employing mechanical oilers. A slow running machine, it requires adequate lubrication without any possibility of leakage of oil onto the metal passing through the trimmer. Design of the Torrington lubricator utilized in this application is shown in *Fig.* 2. Each individual pumping unit is operated from a camshaft ratchet or is rotary driven. As the eccentric moves the plunger forward, lubricant is forced through the upper check valves to deliver oil to the bearing. On the return stroke oil is drawn past the bottom check valve into the cylinder behind the plunger. Delivered

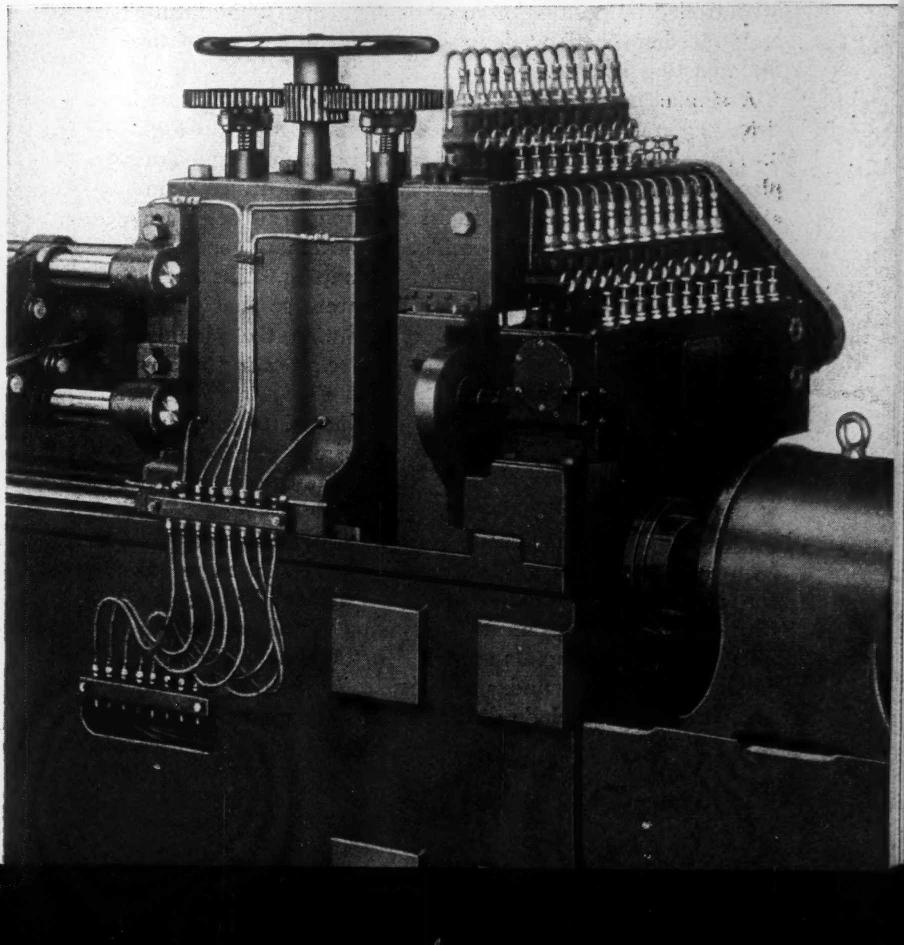


Fig. 1—Right—Trimmer employing mechanical lubricator requires sufficient oil, yet no excess should get on product

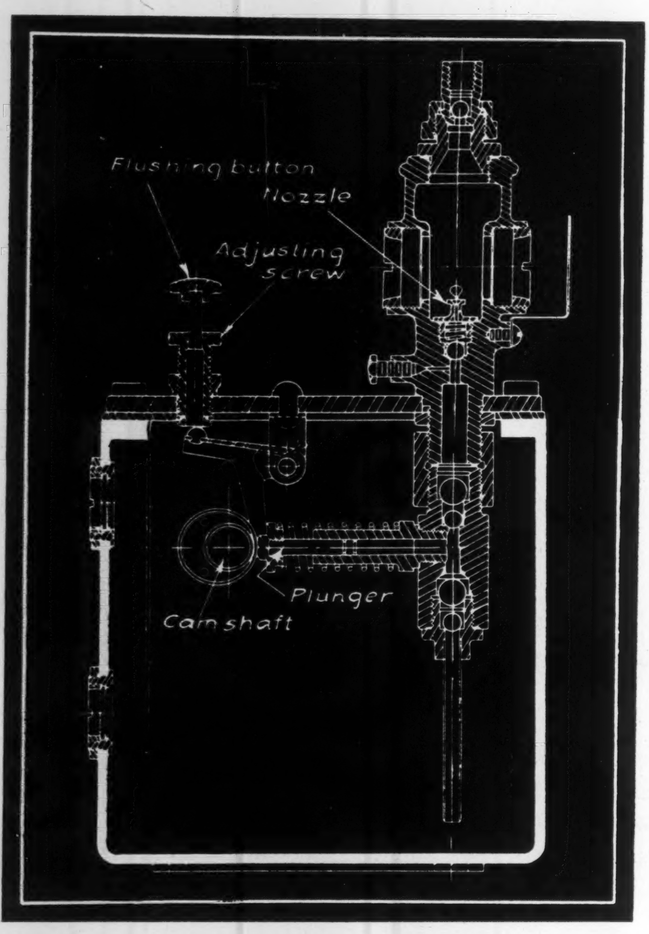


Fig. 2—Section of pump unit for a camshaft-operated mechanical lubricator

oil forms on the nozzle until a drop is large enough to ascend through a transparent liquid in the chamber above, forcing the previously formed drops toward the bearing. This transparent liquid is employed to give visual indication of lubricator operations. Amount of oil delivered is controlled by position of an adjusting screw, while flushing is accomplished by depressing a button connected to the adjusting linkage.

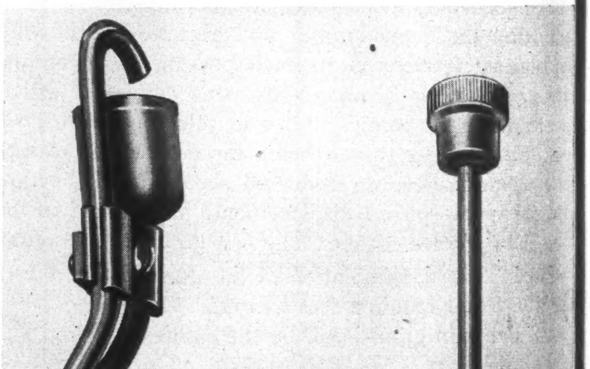
A similar mechanical oiler for either ratchet or rotary drive, separately driven or direct driven, is shown in *Fig.* 3. These units serve one lubrication point each and are placed in line in a multiple compartment and driven from a common shaft. The shaft drives through an eccentric in a yoke to impart both oscillating movement for valving and reciprocating movement for pumping. The angle of the eccentric ring groove is 27 degrees so that when the eccentric makes a complete revolution the plunger makes a total swing of 54 degrees. Reciprocating movement or lift is .212-inch.

Amount of oil delivered may be adjusted to give one drop from several impulses up to ten drops per impulse, this amount being controlled by the adjustment knob at the upper right which extends above the reservoir compartment. This adjustment controls the amount of oil bypassed. An open system, pressure feed is used up to the cup. Gravity then delivers the oil to the bearing through tubing. This necessitates mounting the unit above all the lubrication points served. In the system the sight feeds are enclosed under a transparent window in the compartment to exclude dirt. Central arrangement of the cups in this way also serves to give a quick visual indication of operation.

Another design for a mechanical lubricator is illustrated in *Fig.* 4. Flow of lubricant in an individual pump unit is indicated by arrows. Operation of the spring-loaded plunger alternately delivers lubricant to bearing and sucks it from reservoir. Action of the check valves precludes reverse flow. In this design, developed by Hills McCanna, the oil drops to the bottom of the sight glass for delivery to the bearing. Adjustment of plunger action to control the oil delivery is made by positioning the knurled knob at the right. Delivery is decreased by lifting the rocker arm increasingly from the eccentric. This system will handle pressures up to 2500 pounds per square inch.

Application on a diesel engine of ratchet-driven multiple-pump units is shown in *Fig.* 5, each multiple pump serving 8, 10 or 11 lubrication points. Nathan units are utilized on this diesel and their design principle is indicated in *Fig.* 6. The eccentric at end of ratchet shaft during its revolution raises and lowers as well as oscillates the vertical drive shaft. This motion is transferred to the disk on top of the shaft which engages offset portions of the pistons which are thus also oscillated and reciprocated. During the oscillation each piston rotates about

Fig. 3—Mechanical lubricator pump driven by rotating shaft. Feed is adjusted by amount of bypass

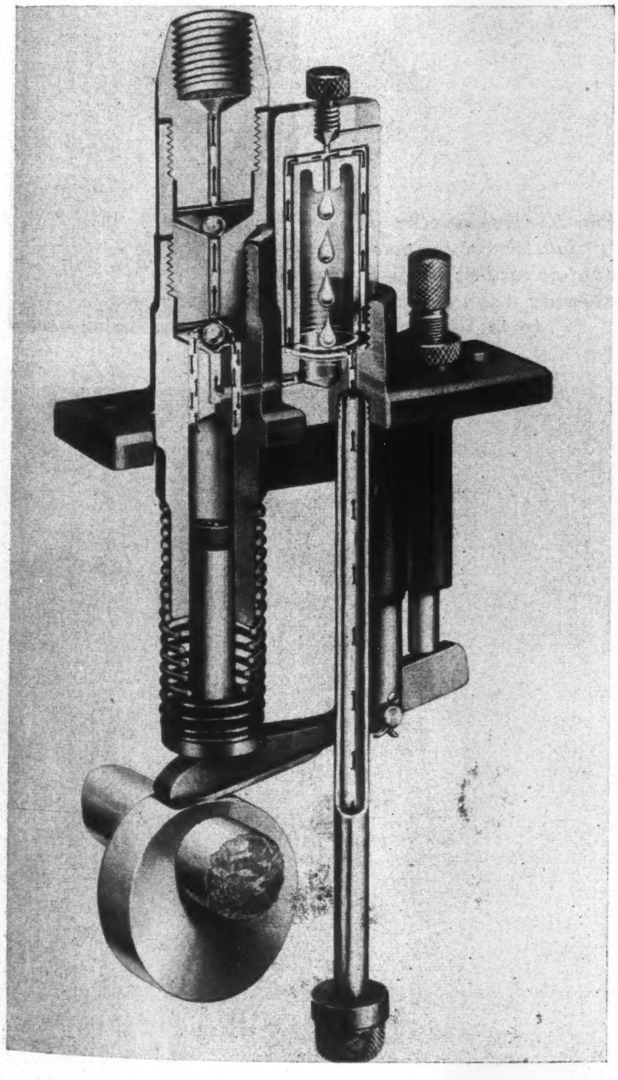


its own axis and the V-shaped port engages alternately with the inlet and with the outlet. During the suction stroke oil is taken into the piston chamber below the piston and during the pressure stroke is expelled from the chamber through the outlet.

In *Fig.* 5, sight-feed glasses are incorporated in each lubrication line. They are arranged centrally in three banks so that operation may be visualized at any time from one location. These indicators have check valves at inlet and outlet ends of the sight chamber which is filled with glycerin. There is always a certain body of oil at the top of the chamber which is expelled by hydraulic action from the drop entering the chamber through the nozzle.

The third group of centralized lubrication systems employs valves, known as the restricted-orifice type. These utilize one central pump as do the piston displacement types discussed in Part I. Representative of this group is the Bijur metering valve in *Fig.* 7. Typical machines to which the system is applied are shown in the head illustrations for this article. One is a business machine for tabulating and the other a bakery machine for dividing dough for baking into loaves. Both types of machines require adequate lubrication but any excess cannot be tolerated.

Fig. 4—Cam-driven unit pump. Sectional view shows flow of oil through sight glass and check valves



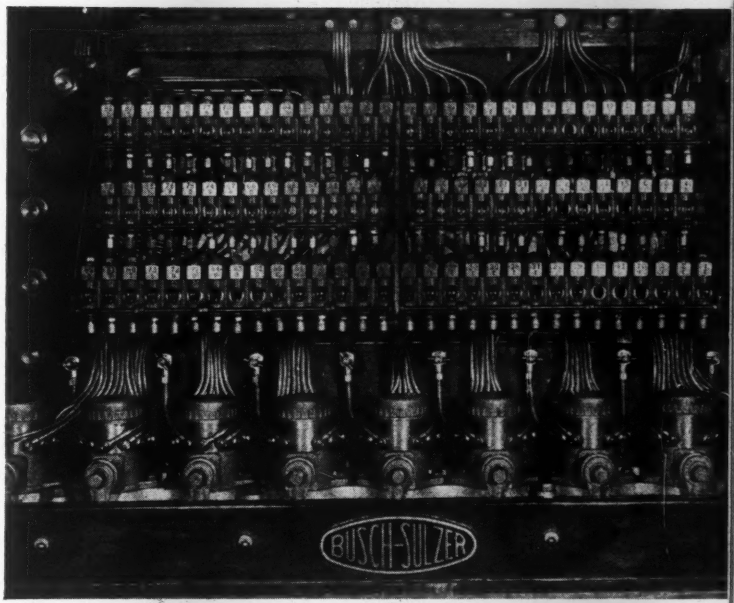


Fig. 5—Multiple-unit pumps with individual sights lubricate 88 points on diesel

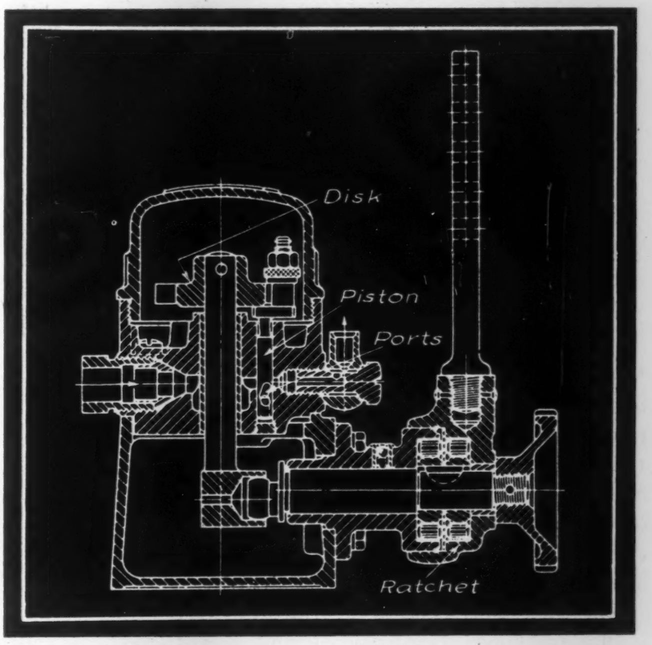


Fig. 6—Sectional view of multiple-pump unit for ratchet drive. Oscillation and reciprocation of pistons control flow

Referring to *Fig.* 7, the valve unit has an orifice of definite metering characteristics selected with relation to the bearing requirements and the lubrication system arrangement. The check valve is a seal to preclude any possibility of siphoning. The orifice has a predominating control of oil flow. Resistance in the tubing lines has negligible effect upon proportioning of the feed. Two systems of pumping lubricant may be used—a constant delivery pump or periodic "shots". For either system the total requirements of the bearings are added and the pumping system selected to deliver that amount.

Another orifice type has an adjustable needle valve as

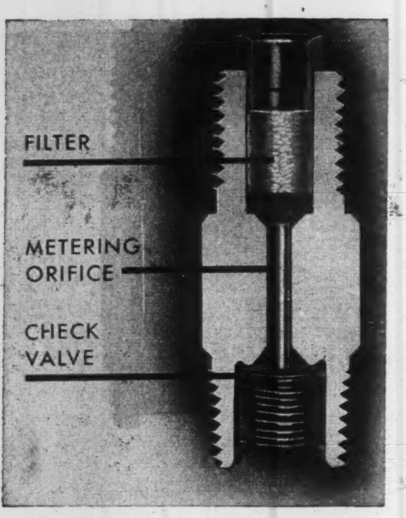
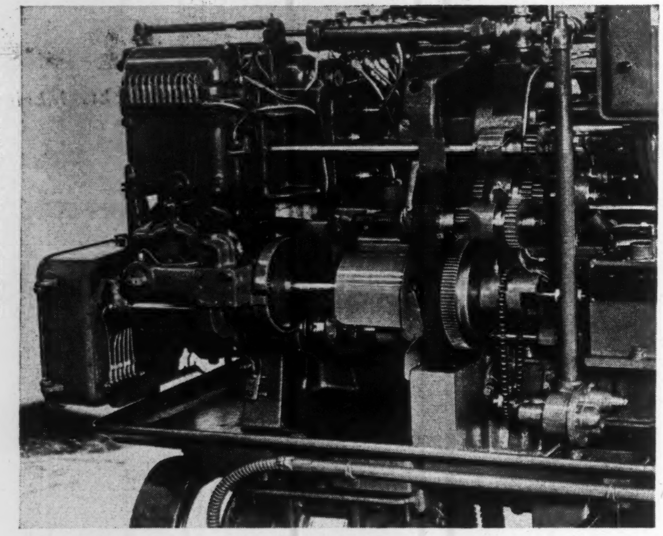


Fig. 7—Left—Restricted - orifice valve proportions lubricant to bearings according to characteristic of orifice employed

Fig. 8—Below—Automatic machine is lubricated by impulse every 45 seconds, developing 150 pounds pressure



designed by the Nugent Co. Sight flows are also built into these valves, either enclosed or open. Two general types of systems are utilized: One delivers oil to the machine by gravity from an overhead reservoir, and the other employs an air-hydraulic system to deliver oil under pressure. Proper air and oil level is maintained in a pressure tank by float and pressure switches.

The Blanchard system, utilizing restricted orifice valves, is manufactured by Rivett Lathe and Grinder and is shown in *Fig.* 8 applied to a high-speed automatic. The pumping unit consists of a three-quart reservoir enclosing a plunger pump driven through a flexible coupling direct from a shaft on the machine. Headers are distributed according to the bearing grouping. A header for eleven feeders is mounted in the upper left portion of the machine, while a header of six feeders may be seen at the lower left. A pulsating flow of lubricant builds up pressure in the lines once every 45 seconds and the feeders are adjusted to meter the lubricant required. The pump is designed to develop above 150 pounds pressure.

Metering valve for this system is shown in *Fig.* 9. Direction of flow is downward against the tapered end of the needle valve which is adjusted so that the pulsations open the valve sufficiently to pass the measured lubricant. In a pulsating system of this kind it is necessary to bleed air from all lines carefully and to apply the system in such a way as to minimize the possibility of trapping air in the system.

An interesting gravity system is shown in *Fig.* 10. Designed by Swift Lubricator, it consists of a glass body reservoir with five outlets. Each outlet can be individually set for the required lubrication and each has a sight feed. Being solenoid operated, it automatically functions by being connected to the machine circuit so that when the machine is operating the lubricator functions. When the machine is stopped the solenoid drops and shuts off the oil supply.

Whether a lubricating system is manual, semiautomatic or fully automatic the choice of a lubricant suited to the bearing and a system suited to the requirements of the machine are essential. A carefully planned system will save lubricant, reduce power consumption, increase bearing life and reduce maintenance. Lubricators are not complicated in their application. Wide range of feed regulation may be had and the source of power for operation usually can be readily arranged.

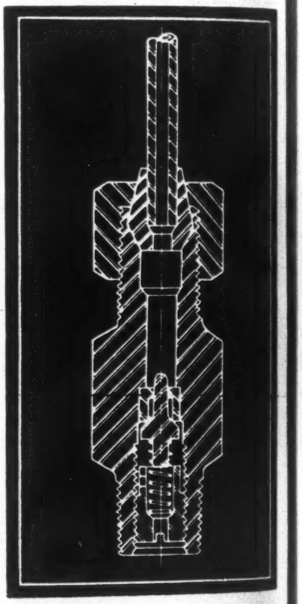
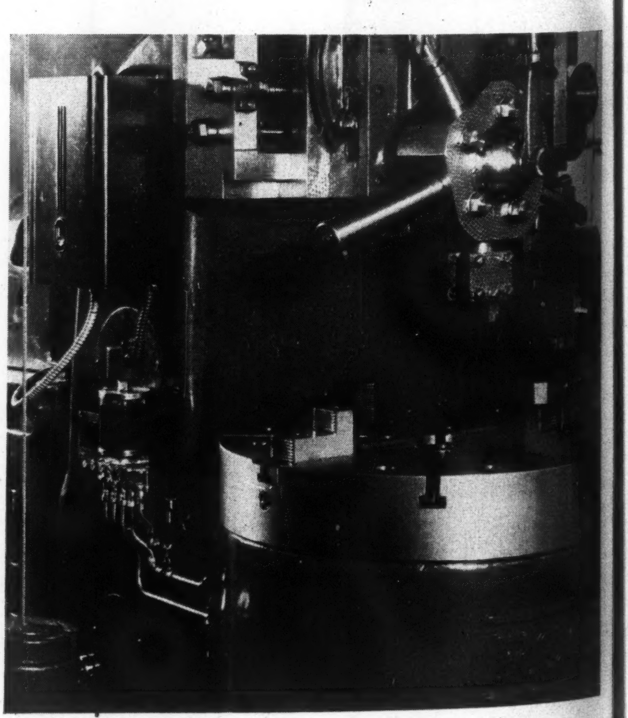


Fig. 9—Right—Pulsating type of restricted orifice operates on momentary pressure to unseat needle valve

Fig. 10—Below—Gravity lubricator is solenoid-controlled to operate only when machine is in use



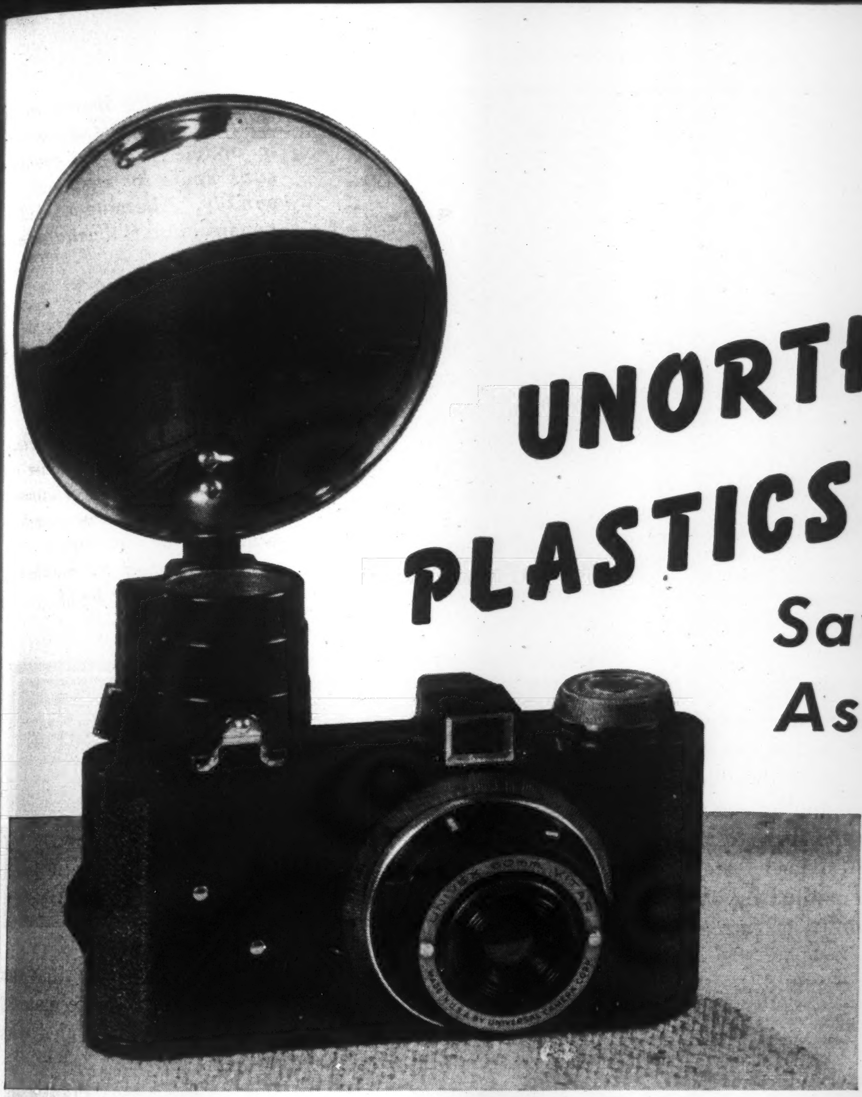


Fig. 1—Above—Snap-lock assembly of parts of this plastic flash camera is made possible by unorthodox "molded-in" constructions (Photo by courtesy of Universal Camera Corp.)

UNORTHODOX PLASTICS DESIGNS

Save Parts and Assembly Time

By K. T. Barrett

Plastics Engineering Department
General Electric Co.

THE unusual in any field is always intriguing. But without practical, useful value the unusual may be of but fleeting interest—a mere "stunt". Thus, what follows is presented not solely because it is representative of the unorthodox, but because it is believed that the design and molding principles discussed may point the way to more widespread development of simpler plastic assemblies capable of being produced at lowest possible costs.

Good design dictates the use of the least number of parts in an assembly consistent with the kind of economical performance and appearance which make the unit an attractive commercial item. When plastics are used in an assembly the designer has a distinct advantage toward attaining this ultimate end, because they possess inherent properties which make possible the use of "molded-in" constructions not feasible with other materials. "Molded-in" construction, in this case, does not refer to the molding in of metal inserts and fabricated units, but rather to the molding of plastic parts into shapes which dispense with the need for additional parts, particu-

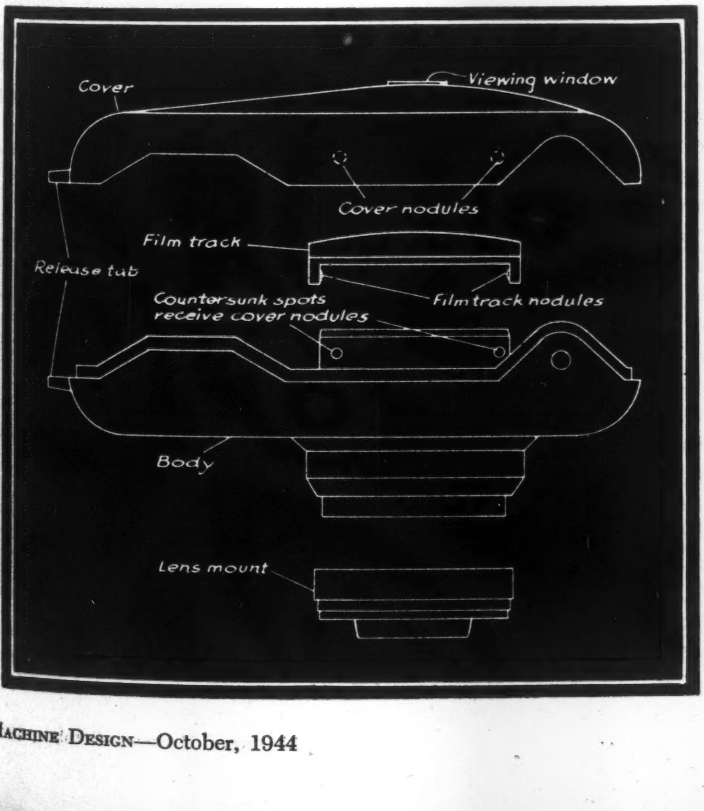


Fig. 2—Left—Molded-in nodules on walls of cover and film track snap into countersunk spots, effectively locking parts together at assembly

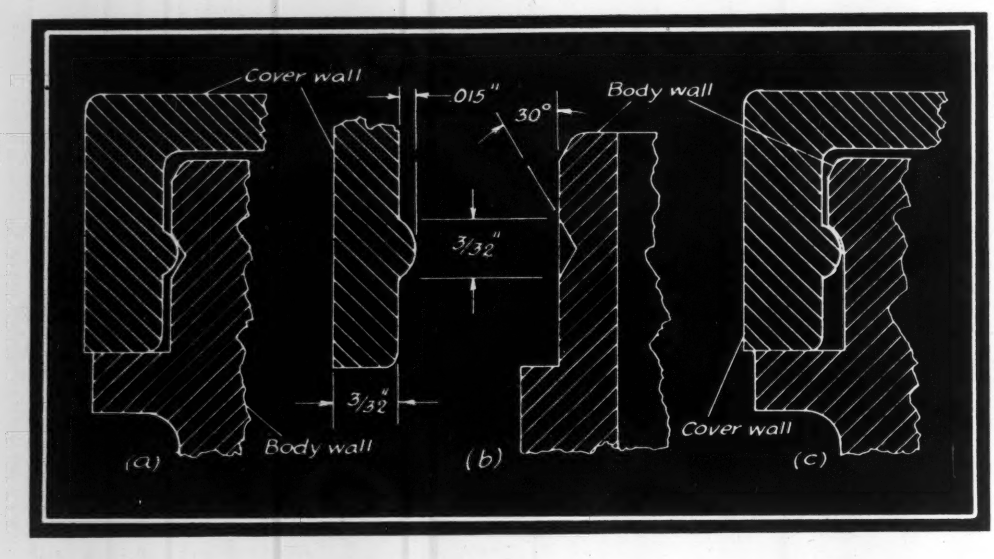


Fig. 3—Left—Shown at a and b are details of molded-in nodules and the counter-sunk spots for snap-lock assembly. Alternate molded-in construction is illustrated at

Fig. 4—Below—Cross section through viewing window recess in back wall of camera cover shows how acetate window is snapped into pocket formed by molded-in annular bead

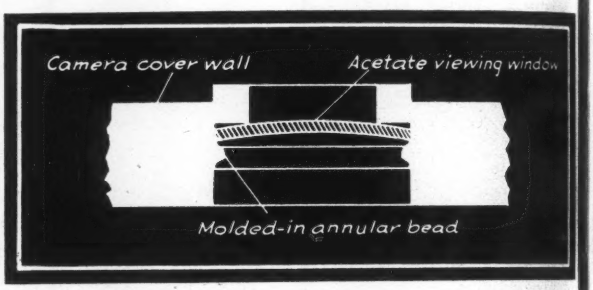
larly various kinds of fastening devices.

An excellent example of a plastic assembly which utilizes such molded-in constructions to achieve substantial savings in parts and assembly time as well as considerable design simplification, is the flash camera shown in *Fig.* 1. In this, the body, cover, film track and lens mount, all are molded of a thermosetting plastic and three of these parts are assembled without the use of standard fasteners such as screws, rivets, eyelets, etc. The method by which they are locked together in final assembly is extremely simple and surprisingly effective.

Nodules Snap Into Spots

Referring to *Fig.* 2—a plan outline drawing of these four major camera parts—it will be seen that small dome-shaped nodules are integrally molded on the inside walls of both the film track and the cover. Countersunk "spots" are machined on the mating walls of the body with a conventional drill point and when the parts are pressed together the nodules snap into the spots to hold the parts together effectively. The fit between the film track and the mating portion of the body is tighter than the fit existing between the cover and the body because the film track is permanently assembled to the body whereas the cover must be removable. Extending tabs are molded integrally on the body and cover at a common end (see *Fig.* 1) and removal of the cover from the body is effected by pressing down on one tab and up on the other, thus creating sufficient separating force between the two parts to spring the nodules on the cover out of the countersunk spots in the body. The snap-locking action involved is shown in greater detail in section *a* and *b* of *Fig.* 3. In section *a*, one of the cover-wall nodules can be seen in final engagement with its spot in the body wall. Note that the nodule is positioned slightly higher than the spot. By this means the nodule, in entering the spot, presses against the sloping wall of the spot and thus urges the cover into firm engagement with the body. Section *b* shows the actual dimensions used for the nodule and spot in this particular case.

Another way of achieving the same type of snap-locking action is shown in section *c* of *Fig.* 3. In this case a projection is molded on the body wall over which the



nodule snaps. It of course will be appreciated that this means of assembly is possible because the plastic material used is flexible enough to permit the part provided with nodules to spring over the mating member.

With regard to the two methods shown by section *a* and *c* of *Fig.* 3, the former gives a better quality assembly, especially where accuracy of fit is of prime importance. When determining which of these constructions to use, the following points should be kept in mind: The projection on the body wall, section *c*, must be molded as indicated in the foregoing, whereas the countersunk spot in the body wall shown in section *a* is machined with a drill point. Also, the construction utilizing the countersunk spot is more substantial than the other as a closer fit of the mating

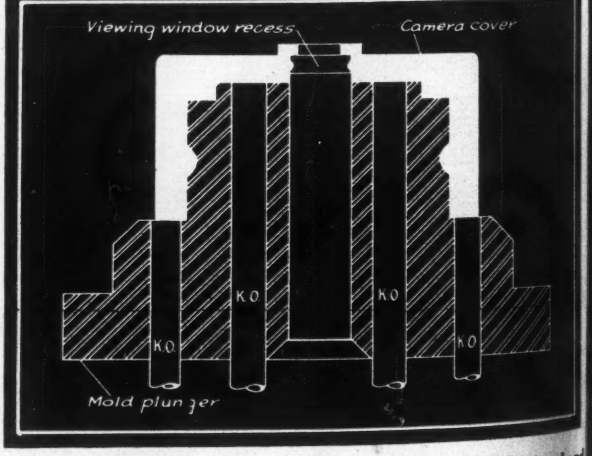


Fig. 5—How nodules (on side walls) and annular bead (in viewing window recess) are "molded-in" on camera cover. Recess and bead are molded with separate pin

parts is possible and this gives better wall support. Again, in the method shown at *a,* closer control of fit can be established because the spot is machined after molding. This permits compensation for variations in the molded parts. In other words, even with the closest kind of control over the molding process, dimensional differences often occur from part to part and, where the projections in this type of construction (section *c*) are molded integrally with the parts, such inherent dimensional variations will lessen control over fit.

The type of construction shown in section *a* costs slightly more than that of section *c*. Nevertheless it has the advantages mentioned in the foregoing plus the fact that it can be used in many applications where the latter cannot. This is because while it is not always possible to mold the required wall projection, in most cases spots or similar depressions can readily be machined.

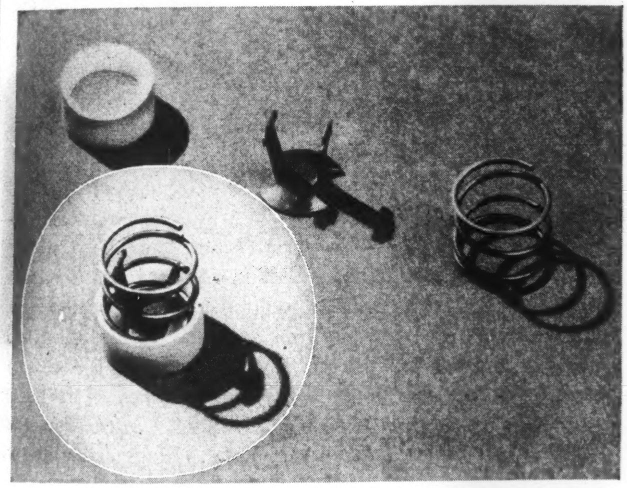
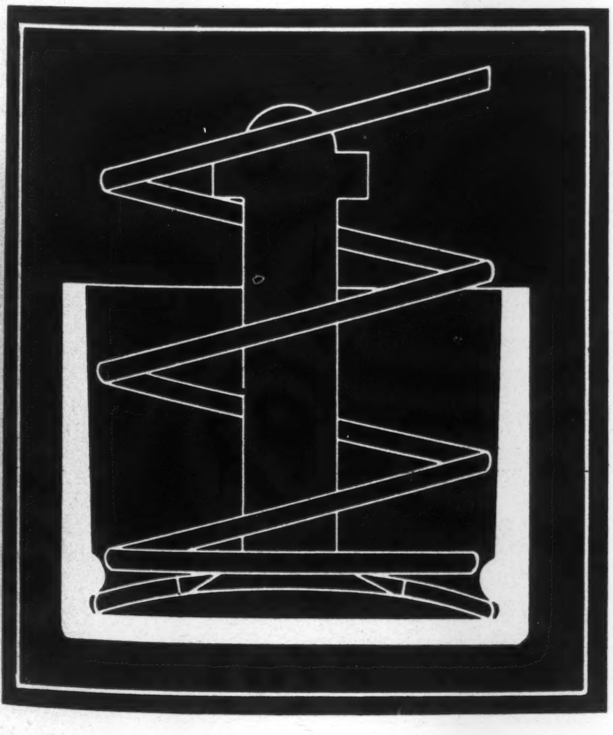


Fig. 6—Above—An example of design simplification through use of molded-in construction is this common pushbutton. Assembly is pictured in insert

Fig. 7—Below—Cross-sectional view of pushbutton above shows how clip member base snaps into place



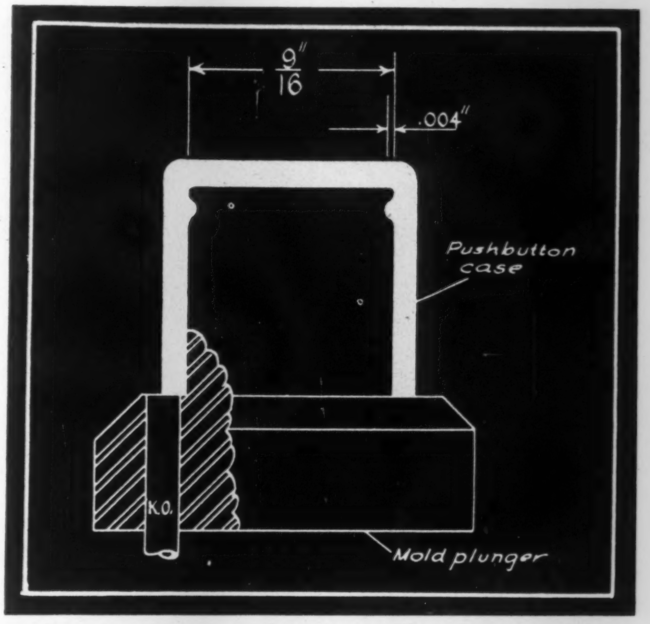


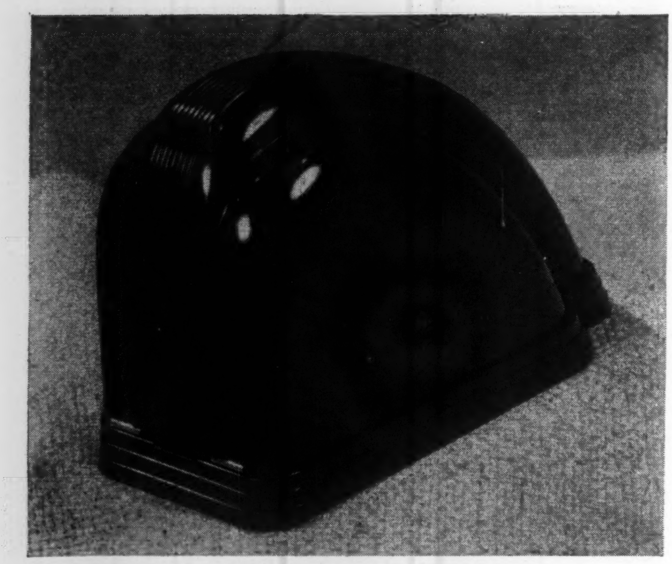
Fig. 8—Pin for molding annular bead in pushbutton case is the mold plunger. Four knockout pins are employed

Almost identical to the above molded-in constructions is that pictured in *Fig.* 4 where an annular bead is molded integrally on the inside diameter of a circular recess to form a pocket into which an acetate disk is snapped. This particular assembly is that employed for inserting the film-viewing window into the cover of the camera shown in *Figs.* 1 and 2.

These constructions all appear to be impossible to mold and draw. Theoretically they are. However, due to the inherent elastic properties of plastics at the completion of the molding cycle plus skillful mold design, they can be molded almost as easily as can parts of more conventional form. Most plastic materials, when hot, are more or less flexible and have sufficient elasticity to permit the trick of springing or stretching the part enough to strip it from the mold. These elastic properties are most pronounced immediately after molding cure, or set, has taken place and it therefore is at this time that projections, depressions or undercuts of a limited size will permit ejection of the parts from the mold without danger of cracking.

Influences of Mold Design

Mold design has a great deal to do with the successful production of such plastic parts and some of the major influencing factors are indicated in the cross-sectional drawing of *Fig.* 5 which shows the mold plunger used in making the camera cover. Two of the constructions referred to above as unorthodox and requiring trick molding are demonstrated; the nodule molding and the annular bead molding. Note the shape and location of the depressions for forming the nodules in the sides of the plunger. They are cup shaped for several reasons. First, they mold or fill easily and permit smooth withdrawal of the part from the mold. Second, as has been indicated, they mold ball or dome-shaped nodules which when assembled with the mating part tend to draw the parts together. Third, they are easily machined in the steel. They are located near



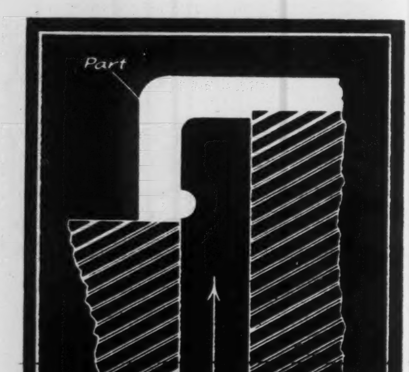


Fig. 9—Above—Design of hinges and catch on this plastic case was greatly simplified by molded-in constructions

Fig. 10—Left—Conventional method of molding projections employs movable mold member, in this case a knockout pin

the cutoff edge of the plunger because at this point there is the least resistance to springing or stripping when the parts are knocked off the plunger in molding.

Knockout (K.O.) pins are located at points in the mold where the part offers the greatest resistance to ejection; that is, near the depressions and also where the strongest surface for knockout is available—in this case, the edge of the part. In the center of the plunger is the grooved pin which molds the annular bead in the viewing window recess. The bevel at the top of the groove is to make stripping easier. Knockout pins are located as close as possible to the pin and are large in diameter so as to present as great a knockout surface against the thin wall as is feasible. Aside from these points the plunger is conventional in design.

These unorthodox design and molding procedures can be utilized to considerable advantage in developing simpler and often more effective assemblies in a great variety of applications. For example, a unit in which the molded-in annular bead can be employed to good effect is the common pushbutton, the three parts of which are pictured in *Fig.* 6 with the assembly shown in the insert. As in the case of the viewing window recess of the camera, the plastic material used is flexible enough to permit stripping the part from the mold without cracking. *Fig.* 7 shows the assembly of the pushbutton in cross section.

The primary difference between the mold for the pushbutton case and the one employed for the recess in the camera cover is that for the recess in the camera cover a separate pin was used, while for the pushbutton case the grooved molding pin is actually the mold plunger. This is shown clearly in *Fig.* 8. Four knockout pins are located around the cutoff edge so that the part is stripped from the mold by using the edge of the wall. Once again, as was the case with the camera cover, the knockout pins are made large to provide sufficient knockout area.

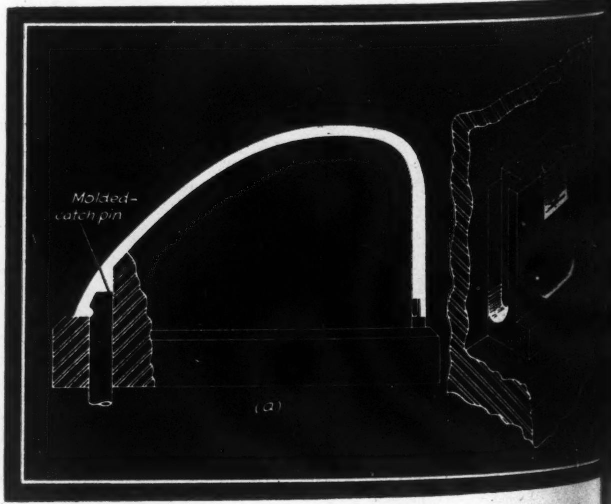
Special "Stripping" Compounds Available

It might be well to point out that stripping a plastic part from a mold is not new. Molders of plastic closures (bottle and jar caps) have used this method for years. In fact, several manufacturers of compounds have developed special materials for this type of molding which permit greater depth of undercut than is possible with standard types of compounds.

Still another field in which molded-in construction is used is represented by the plastic case shown in *Fig.* 9. The cover of this case is assembled by using two metal hinges of special design which snap into place at the back of the unit. A molded snap catch, used on the front end of the case, is created by molding a projection on the cover which engages with a molded undercut on the base. Release of the catch requires only an upward pull and pressure applied to the sides of the cover. It is necessary to machine two undercuts in the hinge pockets of the cover to anchor the upper half of each hinge. Aside from this no other machining is necessary for the hinge assembly; no fixtures or other equipment are required.

In contrast to the above methods of obtaining projections or depressions is the conventional method of molding such plastic areas in a movable or loose mold member which ejects with the molded part, *Fig.* 10. This method is used where greater depth or height is needed or when a square-edge design is required. The snap catch on the plastic cover shown in *Figs.* 11 and 12 was made by this method because the length of the wall was insufficient to permit the strip method without danger of the plastic cracking. As shown in *Fig.* 11*a*, the projection is molded

Fig. 11—Below—View a shows mold for plastic case cover. View b shows mold construction for hinge pockets



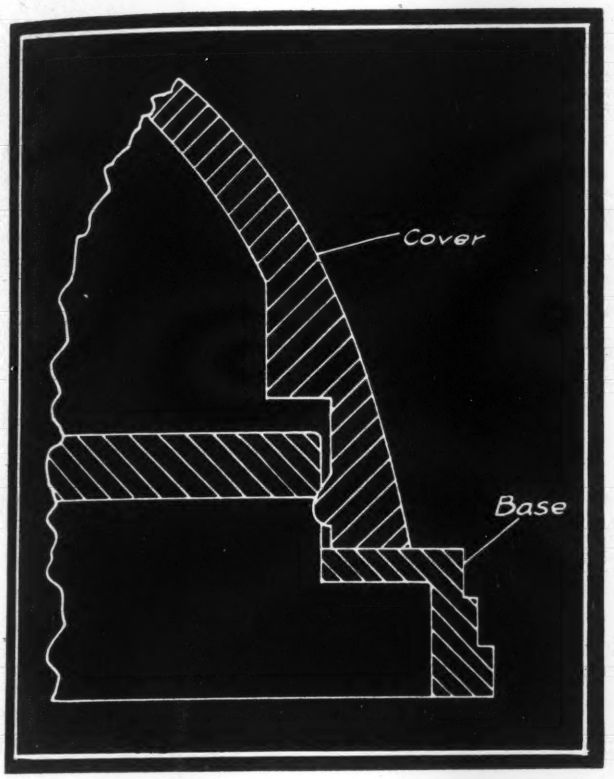
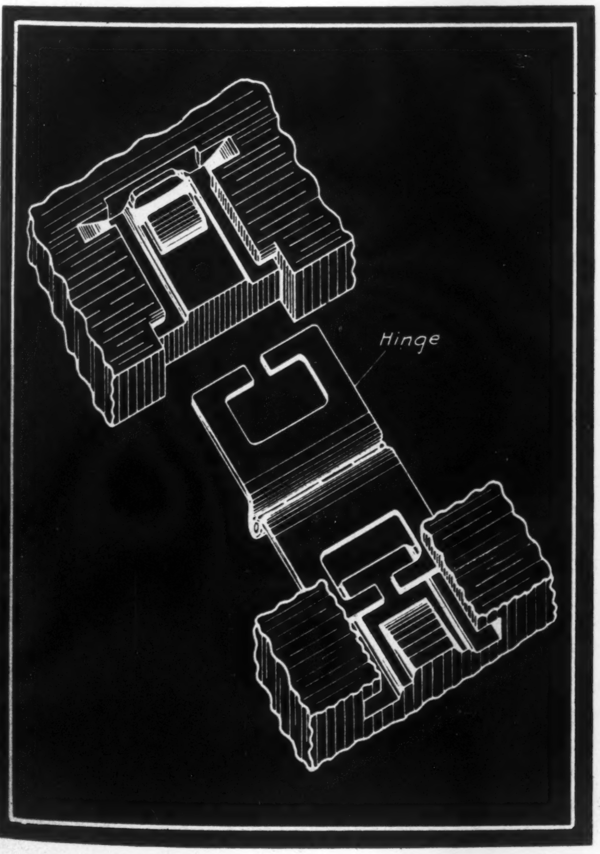


Fig. 12—Above—Cross-sectional view shows how molded-in bead on plastic case cover snaps into undercut molded into base member. Inherent flexibility of plastics makes possible the snap-lock action of this molded-in catch

Fig. 13—Below—Detail of molded-in hinge pockets used in plastic case. Special metal hinge is simply pushed into the pocket grooves until it snaps into place



in a movable pin—in this instance fastened to the knockout bar—that comes up with the part, thus permitting removal of the molded part by a side motion. Where it is impossible to make this side motion due to knockout pin or other interference, the movable pin must be a removable member which will come loose from the mold with the part. It is then removed from the part and replaced in the mold manually.

Mold construction for the hinge pockets is shown in *Fig.* 11*b*. There are two pins designed to mold the pockets for the special hinge. A rib is molded in the center of the pocket and subsequently is cross-slotted by machining to provide the undercut for locking the hinge into the cover. Detail of the pocket is shown in *Fig.* 13. One rectangular knockout pin located between the two pocket-molding pins serves to push the part off this end of the plunger.

Other methods of producing recesses and undercuts are shown in *Figs.* 14 and 15, the former by butting or passing upper and lower mold members and the latter by ma-

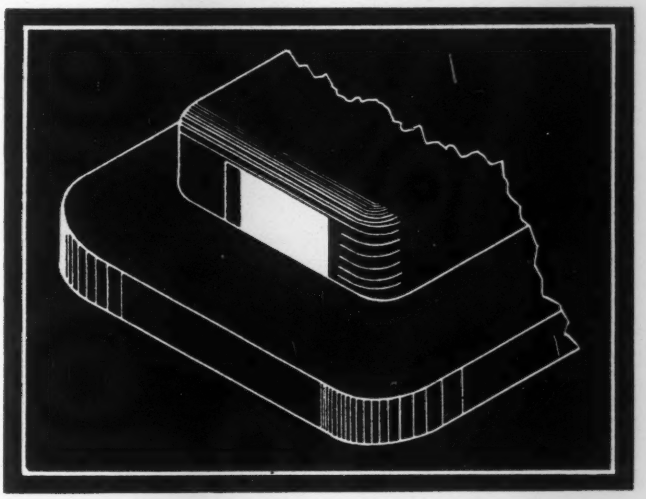
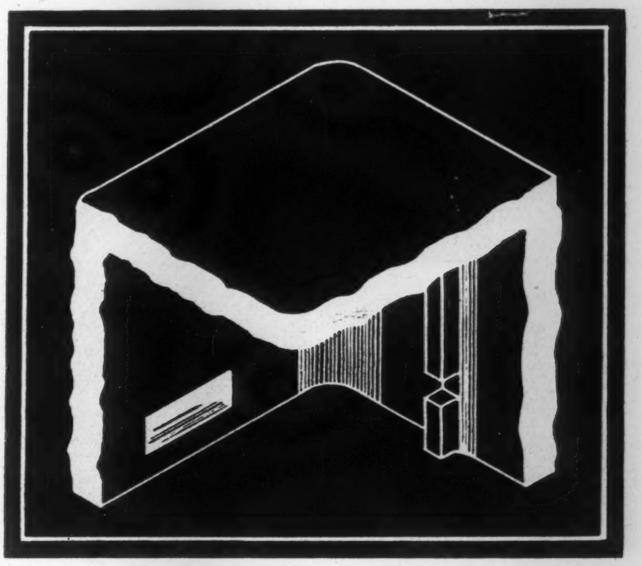


Fig. 14—Above—Type of undercut opening used at front end of the plastic case base to receive bead on cover. Side wall openings of this kind can be readily molded

Fig. 15—Below—Machined undercuts such as these are used where molded-in undercuts are not practicable



chining a slot in the sidewall of the molded part. Both of these methods were used on the plastic case previously discussed—on the front of the base, *Fig.* 14, and on the back end of the cover, *Fig.* 15, in conjunction with the molded hinge-pocket.

Incorporated in the mold for the base of the plastic case is the design for undercuts shown in *Fig.* 16. The undercut molded in the front of the base is similar to that shown in *Fig.* 14 and receives the cover catch. In this partial cross section (*Fig.* 16) the mold is shown in its closed position. Note how molding of this apparent undercut is achieved by allowing a portion of the upper and lower members of the mold to pass each other. The members pass within approximately .003-inch—or just enough to insure clearance. The small amount of flash which forms at this point is removed quickly and easily in a finishing operation. Hinge pockets and undercuts on the back end of the base result from having the plunger butt the hinge pocket pins. *Fig.* 17 shows this in a partial cross section of the mold in closed position. Knockout pins are located in the upper member of the mold to eliminate any knockout marks on the outside of the part where appearance is important. The molded part is retained on this member by the use of pickups which are slight grooves machined into the side wall of the mold member that must retain the part for knockout. Without these pickups the part would not adhere.

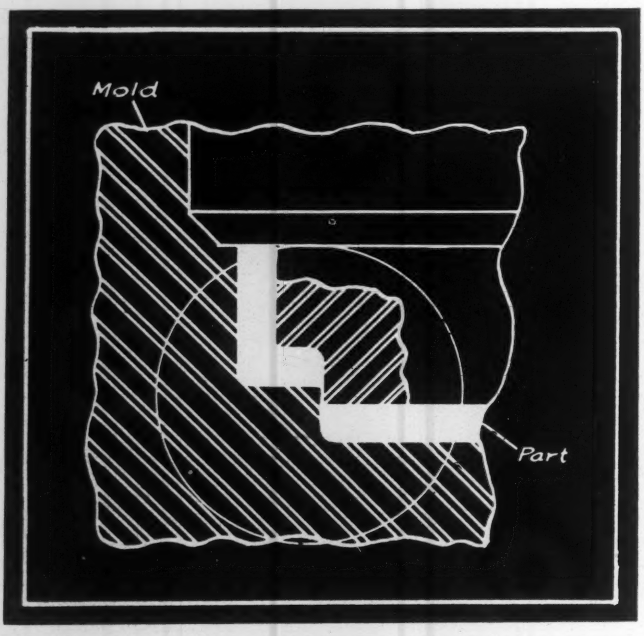
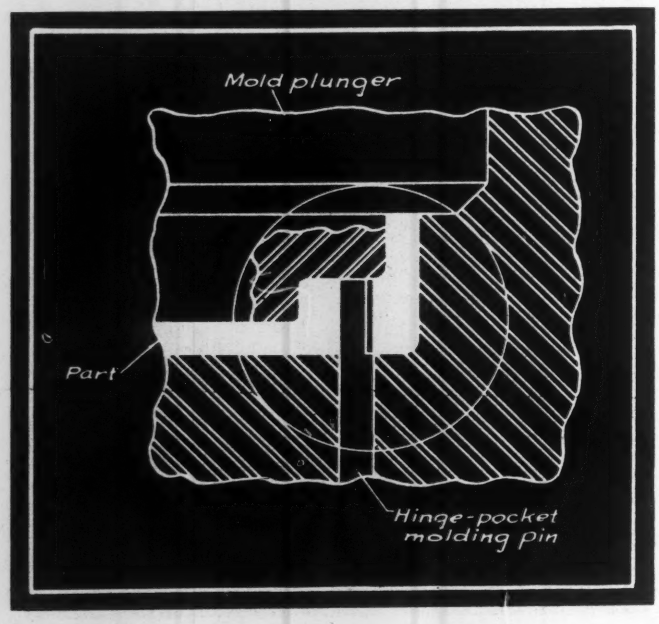


Fig. 16—Above—How mold is made to produce undercut like that pictured in Fig. 14. Upper and lower mold members pass at undercut with minimum of clearance

Fig. 17—Below—Hinge pockets and undercuts of plastic case back end are molded by butting mold plunger and pins



Design Precautions

In designing parts utilizing these various types of molded-in construction, it is well to bear in mind that the wall on which the projection or depression is located must be thin in proportion to its length. The design must also permit mold construction that will allow knockouts to be applied near the area where the projection or depression is located.

Dimensional limitations of stripped undercuts or projections vary, depending on the type of material, size and design of part. Generally, their extent must be worked out for each application. However, depths of .005 to .015-inch are not uncommon.

Many variations of the methods herein discussed may be made to suit the particular design problem involved. It is evident from the foregoing that much may be gained, when designing for simplicity of assembly, by taking advantage of the inherent properties of plastics which permit the use of the methods described. However, before final design specifications are drawn up, it is best to consult with the molder to make sure that the limitations of these unorthodox procedures have not been exceeded.

Largest Blimp Uses "Air Brakes"

NAVY'S newest and largest blimp, the M-1, can use its propellers as "brakes" in the first adaptation of fully-controllable reversible aircraft propellers to lighter-than-air craft. Operation of the propellers developed by the propeller division of Curtiss-Wright Corp., is accomplished without reversing their direction. The new blimp can be brought to a virtual standstill in midair by reversing the blade angles of the electric propellers to create reverse or backward thrust. Use of this reverse-pitch feature in combination with fully controlled pitch of the propeller for normal forward thrust, has greatly facilitated handling and landing.

Engineers report that the controllable feature contributes to faster take-off when the blimp is heavily loaded. The flight engineer sets the blades at take-off angle, speeds up the engine, and the blimp, traveling on its landing wheel and using its underside for lifting purposes, makes a running takeoff.

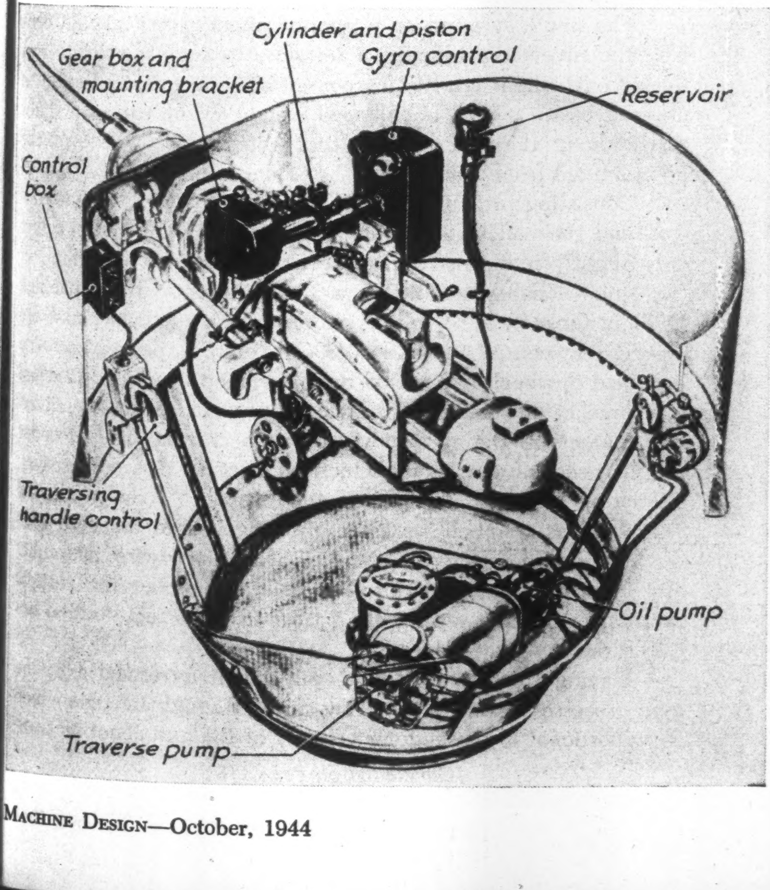
First of several of its type to be built for antisubmarine patrol duty by the Goodyear Aircraft Corp. of Akron, Ohio, the new blimp is powered by two 500-horsepower engines.

More Bull's-Eyes with New Gun Stabilizer!

By C. R. Hanna and L. B. Lynn
Westinghouse Research Laboratories

Fig. 1—Above—Gun stabilizer, now standard equipment on American tanks, permits accurate firing while the tank is in motion

Fig. 2—Below—Stabilizer, in tank turret, comprises gyro control attached to gun, oil pump and control unit, and hydraulic actuating cylinder



ENABLING gunners in American tanks to fire accurately while racing across rough battlefields, the gyroscopic tank-gun stabilizer gives a decisive offensive advantage over enemy tanks which ordinarily must stop to fire. Until the adoption of the stabilizer it was accepted military form for half of a group of tanks to stop and fire, then advance while the others stopped. Under this system, of course, only half of the guns could fire at one time.

Inasmuch as many of these stabilizers now have fallen into enemy hands, the secrecy which has surrounded the details of their design has been partially lifted, making it possible to discuss the major design features of the device in the present article.

A perspective view of the inside of the gun turret on a tank is shown in *Fig.* 2. The gunner controls the elevation of the gun with his right hand by means of the handwheel shown, and traverses the turret with his left hand, using the pistol-grip which also is shown in *Fig.* 2. The stabilizer holds within close limits the elevation of the gun in the position set by the gunner, regardless of the pitching and rolling of the tank.

In the development of the stabilizer it was found that the principal disturbances average 1½ cycles per second corresponding to the pitching frequency of the tank on its springs, while angular velocities are about 30 degrees per second and accelerations about 300 degrees per second per

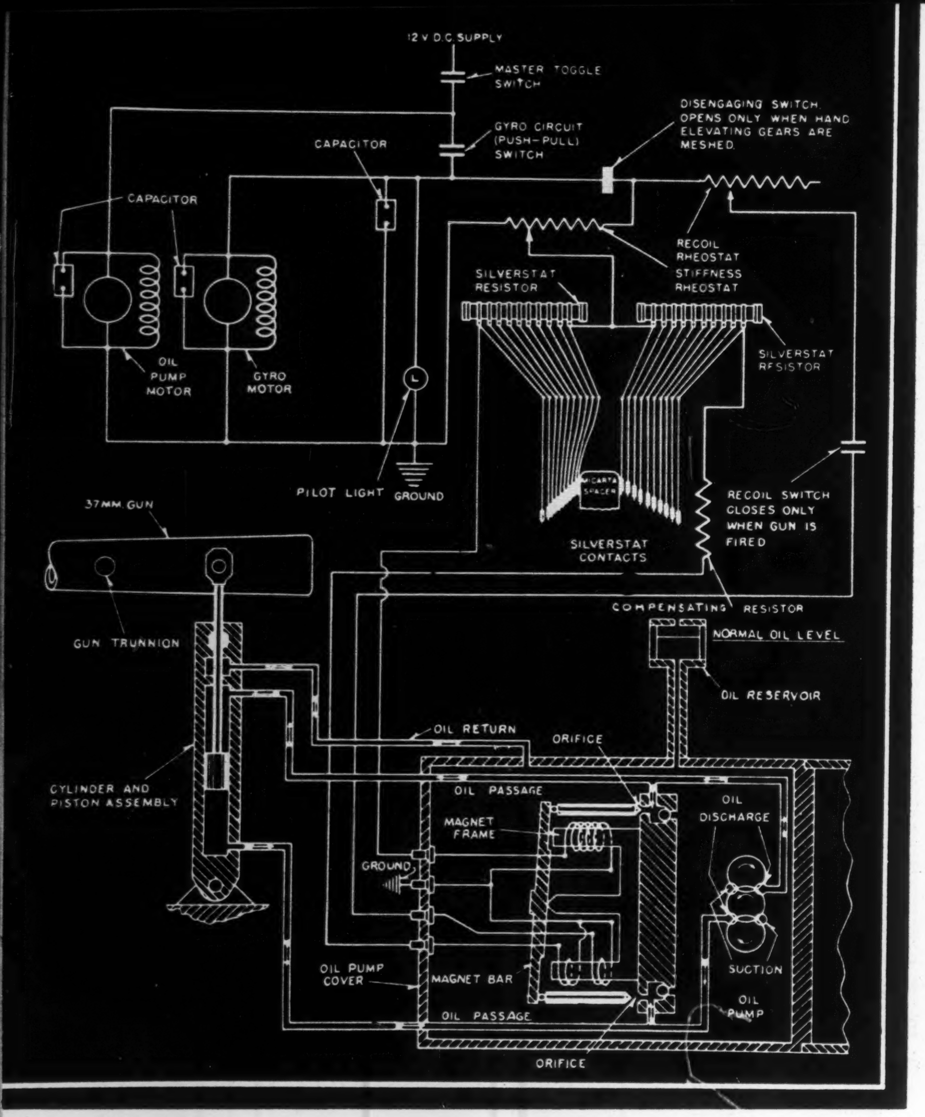
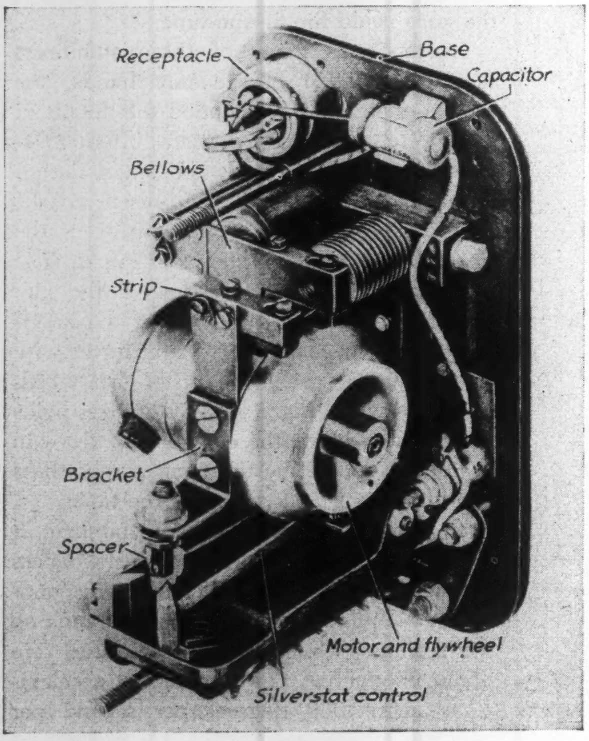

12 V D.C SUPPLY
MASTER TOGGLE SWITCH
GYRO CIRCUIT (PUSH-PULL) SWITCH
DISENGAGING SWITCH OPENS ONLY WHEN HAND ELEVATING GEARS ARE MESHED
CAPACITOR
CAPACITOR
RECOIL RHEOSTAT
STIFFNESS RHEOSTAT
SILVERSTAT RESISTOR
SILVERSTAT RESISTOR
OIL PUMP MOTOR
GYRO MOTOR
L
PILOT LIGHT
GROUND
37MM GUN
MICARTA SPACER
SILVERSTAT CONTACTS
RECOIL SWITCH CLOSES ONLY WHEN GUN IS FIRED
COMPENSATING RESISTOR
NORMAL OIL LEVEL
OIL RESERVOIR
GUN TRUNNION
CYLINDER AND PISTON ASSEMBLY
OIL RETURN
ORIFICE
OIL PASSAGE
MAGNET FRAME
OIL DISCHARGE
GROUND
SUCTION
OIL PUMP
OIL PUMP COVER
MAGNET BAR
OIL PASSAGE
ORIFICE

Fig. 3—Above—Schematic diagram shows electric and hydraulic circuits of the gyro stabilizer

Fig. 4—Below—Mono-gyro control unit, shown with cover removed, responds primarily to velocity


Receptacle
Base
Capacitor
Bellows
Strip
Bracket
Spacer
Motor and flywheel
Silverstat control

second. The comparatively great inertia of the gun barrel is a favorable element, for if balanced and unhindered the gun would remain at a constant angle. Moreover, as the tank pitches, the comparatively small trunnion friction would give only low angular accelerations of the gun and relatively close balancing of the mass about the trunnions would minimize the acceleration torques arising from the vertical and horizontal movements of the tank.

Actual field conditions, however, are severe because of excessive oscillations, dust, moisture, and wide temperature ranges. In addition, the cramped and limited tank turret space imposes the necessity for simplicity and compactness in the design of a stabilizer.

Components of Stabilizer System

Basic components of the system, *Figs.* 2 and 3, are (1) the gyro motor, (2) the silverstat regulator, (3) the oil pump system including the electromagnetically controlled valves, and (4) the piston and cylinder assembly. The gyro control box, *Fig.* 4, is fastened to the gun. Tank fluctuations tending to alter its position actuate the gyro unit which, through the silverstat, varies the current to the electromagnet valves. The valves in turn operate to increase or decrease the oil pressure above and below the piston, in accordance with the signal current. Since the piston is fixed to the gun, movement of oil to the low-pressure side maintains the elevation of the gun in the aimed position.

The single gyro, which is pivoted about a vertical axis, controls the silverstats through its response to angular velocity and through its slight gravity response. The gravity response is effected by an offside unbalanced weight which causes a slight deflection of the silverstats in the proper sense whenever the gyro is tilted from vertical, and a gradual return occurs.

Consisting principally of the gyro-motor, the silverstat control, and the bellows assembly, *Fig.* 4, the monogyro control is only slightly influenced by an acceleration or sharp turning of the tank. The gyro motor is a 12-volt direct-current machine for light tanks or a 24-volt direct-current for medium tanks, operating between 12,500 and 16,000 revolutions per minute. The balanced flywheel is mounted on antifriction bearings. Attached to a bracket on the motor, a spacer opens and closes the silverstat contacts as the gyro moves on its bearings. The silverstat has two sets of ten leaves which connect to taps on resistors, regulating the current through the magnetic coils on the oil pump valves. A bellows assembly, attached to the gyro control base and connected to the gyro with piano wire, hydraulically damps the gyro to prevent resonance about the vertical precession axis and returns the spacer to its correct position between the silverstat leaves.

Having freedom of action only about a vertical axis, the gyro precesses against a centering spring through an angle which is proportional to the angular velocity of the gun about its trun-

(*Concluded on Page* 118)

Fig. 26—Shocks, vibration and noise from this injection-molding machine are effectively insulated from the surroundings by felt blocks spaced under the footing

VIBRATION and NOISE—Causes and Cures

By Colin Carmichael

Part III—Isolation Materials

RESILIENT mountings for vibration and noise isolation may employ a variety of materials. Steel and rubber often are incorporated in unit type mountings, discussed and illustrated in last month's article, while rubber, felt, cork and other materials may be applied in the form of sheets or pads. In addition to the resilient characteristics useful in vibration isolation, other properties of materials such as damping or absorbing capacity are valuable in the suppression of vibration and noise and are discussed in the present article.

Felt is an effective and easily applied material available in sheets or pads and in a variety of different hardnesses. Its resilience enables it to be used for vibration isolation in similar applications to many of these discussed in last month's article. The principle of application is the same—provision of

Fig. 27—Right—Felt pads may be cut to fit the machine footing, as in the case of this stitcher

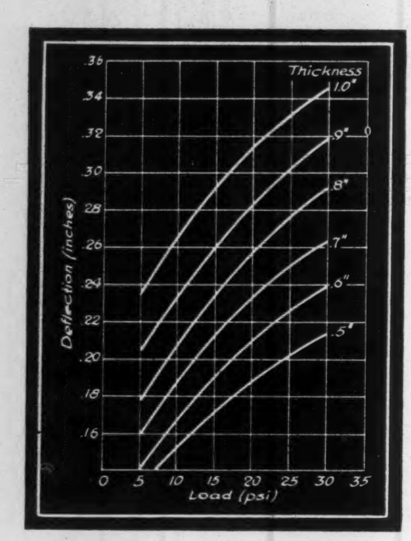


Fig. 28—Left—Curves show static deflection under load for various thicknesses of a typical vibration-absorbing felt

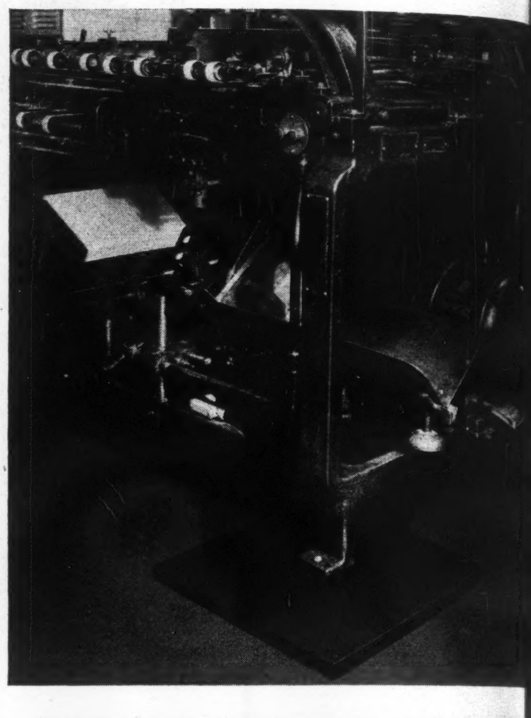


Fig. 29 — Right — Low unit loading for cellular rubber mounting pads is obtained by using metal plates to extend area of footing

an elastic suspension with a natural frequency less than the disturbing frequency.

Selection of felt mounting pads is based primarily upon the weight of the machine to be isolated and the area of the footing, *Figs*. 26 and 27. Each grade of material is designed to carry a certain range of loading, hence the first step is the calculation of the load to be carried per unit area. Load-deflection curves for a typical grade of felt suitable for vibration isolation are shown in *Fig*. 28, this particular grade being recommended for loading between 10 and 20 pounds per square inch.

It is, of course, not necessary that the area of the felt pad be exactly equal to the footing area provided on the machine. In fact, except for vibrations of audible frequency, isolation efficiency generally is highest near the maximum recommended load. On the other hand, if the footing area is so small as to result in excessive loading, a stiff steel plate may be fastened to the machine foot to extend the area. An example of this type of design, as applied to cellular rubber pads, is shown in *Fig*. 29.

Inasmuch as static deflection is a major factor in determining isolation characteristics (Equation 3, Part II), felt and other mountings should be so designed that equal deflections occur at each point of support. Further, because vibration isolation depends for its effectiveness on the provision of a high ratio of disturbing to natural frequency, (*Fig*. 15, Part II), it is usually recommended that as great a thickness of felt as practicable be used. This gives a large static deflection (*Fig*. 28) and results in low natural frequency.

Estimating Natural Frequency

In applying resilient materials to vibration isolation, it has been pointed out that the natural frequency, f_n, is a function of static deflection, d. Where the stiffness k (load-deflection ratio) is constant, as in a steel spring, this is a simple function (Equation 1, Part II). For felt and some other nonmetallic materials, however, the stiffness varies with the load, as the curves in *Fig*. 28 show; these would be straight lines if k were constant. Consequently the simple relation is not strictly applicable.

One method of determining natural frequency is to conduct dynamic tests on the material, expressing the results in the form of a curve, *Fig*. 30, which can be used to predict the performance of any setup using the same grade of felt. The basis of calculation is as follows. The relation between natural frequency, cycles per second, and static deflection, inches, is $f_n = 3.13/\sqrt{d}$. Also, the elastic modulus of any material may be expressed as $E = \text{stress/strain} = p/(d/t)$, where p is the pressure or stress, d the deflection, and t the thickness in the direction of the pressure. Substituting into this equation the value of d from the previous one, $E = .102ptf_n^2$. The curve in *Fig*. 30 represents values of E calculated from this equation using test values of p, t and f_n. For any loading p the value of E may be found from the curve and the natural frequency calculated if this grade is used.

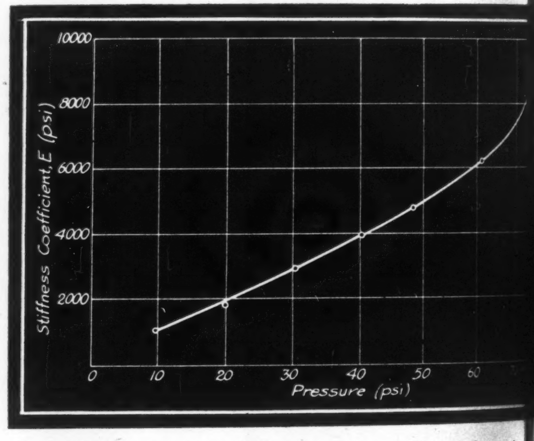


Fig. 30—Dynamic stiffness curve aids in determining natural frequency of felt mounting

It is of interest to note that the stiffness of the felt in *Fig*. 30 is almost directly proportional to the loading, hence the natural frequency is practically constant for a particular thickness and independent of the loading.

In selecting a grade of felt for use with bolts, the load due to the tightening of the bolts must be added to that of the machine in arriving at the figure for unit loading. To prevent the transmission of vibration through the bolt itself, a design similar to that shown in *Fig*. 31 should be used. Inasmuch as bolts detract from mounting efficiency, their use should be avoided, as in the machine pictured in *Fig.* 32, unless essential for securing the machine against external loads or excessive disturbing forces.

Discussion so far has been concerned with sustained or "steady state" forced vibrations such as are produced by continuously running machines. Shock load resulting from impacts or sudden pressure rise creates a transient vibration which it is one of the functions of vibration mountings to absorb. A transient vibration started by a shock persists at the natural frequency and with an amplitude which diminishes according to the amount of friction or "damping" present. Accordingly, materials which possess internal damping or energy-absorbing capacity are desirable for dealing with shock loads.

In such materials the energy stored while it is being compressed is not all returned when it is unloaded, the difference in energy being absorbed and dissipated in the form of heat. The curves in *Fig.* 33 show what happens when various grades of felt are heavily loaded and then relieved of load. Inasmuch as the area between each curve and the deflection scale represents work done, it is evident that more than half of the energy is absorbed. While the heavy loading exaggerates the effect, the same principle applies to ordinary loading and, in varying degree, to other materials such as rubber and cork. Friction in leaf springs and hydraulic shock absorbers produce the same effect.

In applying rubber it is important to remember that this material is practically incompressible, meaning that its volume cannot be changed, hence it must be free to distort. Short narrow blocks can be used in compression, as mentioned in Part II, but large sheets or slabs are ineffective. Cellular rubber, however, which is filled with air pockets, is compressible and forms an efficient type of support for certain applications, such as shown in *Fig.* 29. The most extensive use of rubber is in shear mountings.

Cork is highly compressible and, in the form of corkboard, is applied in large sheets or slabs, often under concrete blocks. Natural cork mounting units also are available, the cork being bound between steel plates or rolled sections. Advantages claimed for cork include light weight, compressibility, resilience, resistance to moisture and chemicals, and frictional properties. As in the case of other mounting materials, cork must be loaded sufficiently to insure a low natural frequency, hence if the load is light the material should be applied over a limited area.

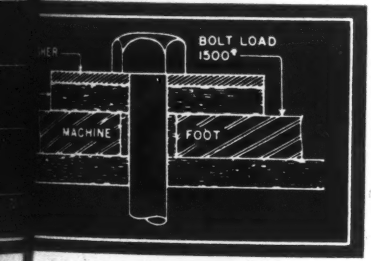


Fig. 31—Left—When bolts are used with felt mounting it is necessary to isolate them from the machine to avoid bridging through the bolt

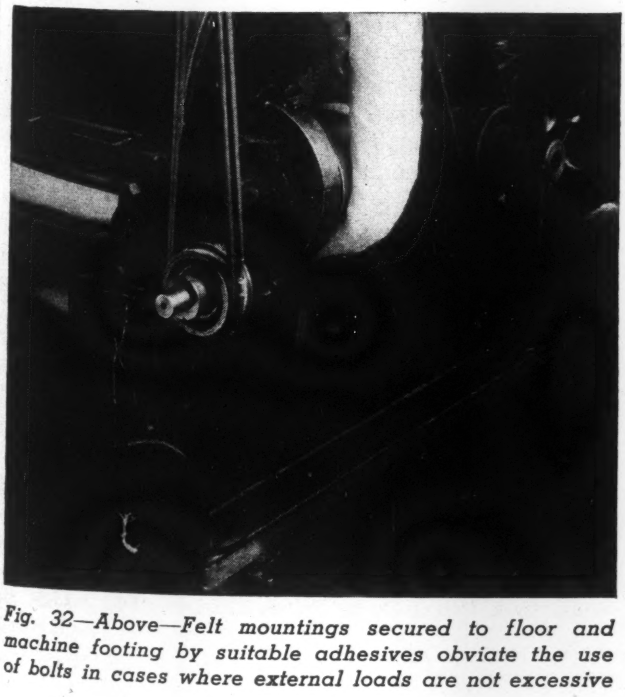


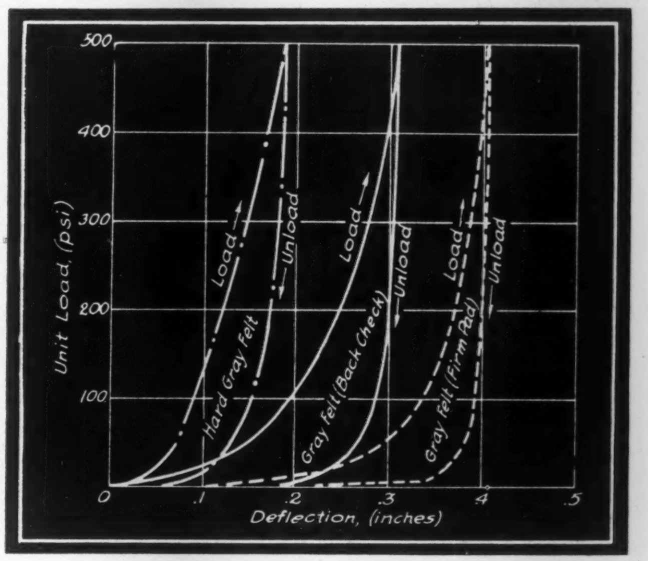
Fig. 32—Above—Felt mountings secured to floor and machine footing by suitable adhesives obviate the use of bolts in cases where external loads are not excessive

Combatting Noise

While vibration mountings often are highly effective in reducing noise, insulation against noise sometimes requires special treatment. In considering materials for combatting noise, it is important to distinguish between sound absorption and sound insulation. Absorption means the absence of reflection, and the term is applied to the acoustic treatment of walls, floors and ceilings of enclosures, the standard of comparison being an open window. By not reflecting sound waves, absorbing materials substantially reduce the noise level within an enclosure such as the cabin of an airplane, *Fig.* 34. Materials widely used for this purpose include kapok felt, cellular cork blocks, and various compositions of rock wool, glass wool, etc., with ceramics or cement.

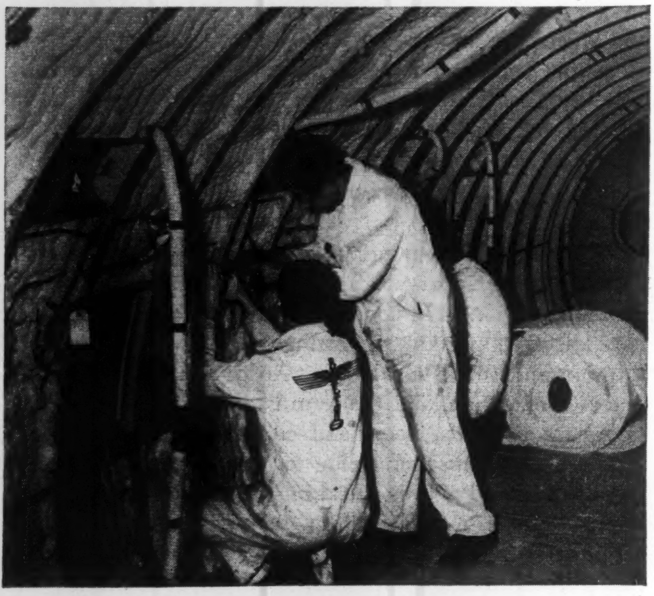
Sound insulation, or the prevention of sound transmission, involves somewhat different principles. Metals and many other materials propagate sound waves effectively with velocities much higher than in air. For example, the velocity of sound in steel is sixteen times that in air. When sound waves pass from one material to another, reflection,

Fig. 33—Below—Load-unload curves for three grades of felt show energy loss which causes vibration damping



transmission and absorption all take place. Maximum reflection occurs when the two materials in contact have widely different values of "resistance to sound conduction" (R.S.C.). Numerically equal to the velocity of sound in the material times the density, R.S.C. is equal approximately to 4860 for steel, 14 for cork, 9 for rubber and only .05 for air. The discontinuities at the two surfaces of a ¼-inch steel plate in air may result in as much as 30 decibels transmission loss, due to high reflection, corresponding to an energy reduction of 99.9 per cent.

Fig. 34—Below—Sound-proofing of airplane cabin is effected by lining the interior with kapok felt



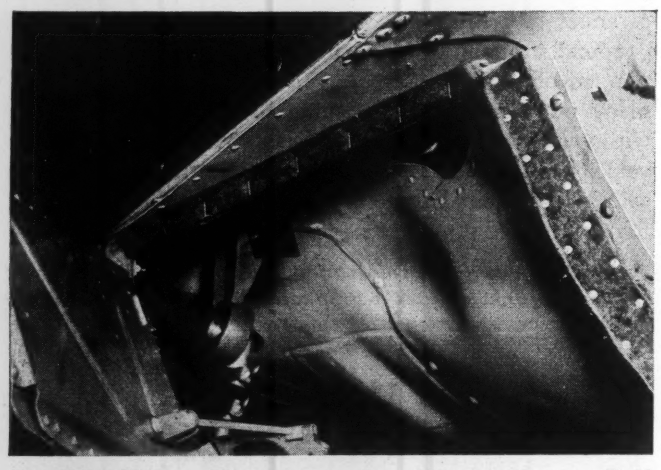


Fig. 35—Above—Flaps for cooling-air exit duct on P-40 fighter close against sound-deadening felt sealing strip secured to metal by stitching (top) and by riveting (side)

However, the resonance characteristics of partitions—for example, machine enclosures—are an important factor in the transmission of sound, inasmuch as the sound waves may cause vibrations or "oil-canning" which may even magnify the transmitted sound. Sprayed-on sound-deadening materials such as bituminous compounds are effective in damping low-frequency vibrations of large amplitude. High-frequency sounds are most effectively damped by the application of a suitable nondrying putty.

Energy not transmitted is either absorbed or reflected, hence by providing multiple discontinuities at each of which energy is reflected, high absorption may be obtained. This principle is the basis of a unique type of vibration absorber (patent applied for) which is claimed to be particularly effective in preventing the transmission of violent shock, as well as functioning successfully as a vibration mounting. Known as the Molecular Vibration Absorber, the mounting consists of a series of thin sheets of metal—as many as fifty—stacked together and enclosed in an airtight welded jacket. The plates are so assembled that each surface is covered with a film of oil whose thickness does not exceed the radius of molecular attraction—approximately one-quarter of a millionth of an inch—and the air space separating the oil films is of the same order of magnitude, equal, in fact, to the mean free path of the molecules.

Absorption of energy occurs primarily in the thin air film. Energized air molecules receiving impacts from the adjacent plate pass to the opposite plate without reflection from other gas molecules because the distance is equal to the mean free path. Impact of an air molecule with the metal plate is inelastic and the resulting energy is dissipated by radiation. If the air space were greater, elastic impacts between air molecules would occur and the unit would heat up.

Reduces Impact to Steady Pressure

Comparing the action of the absorber with that of a resilient mounting, it will be recalled that vibration forces in the latter case are, in effect, reduced by increasing the distance over which the force acts. The molecular vibration absorber, on the other hand, reduces force by increasing the time of passage of an impulse. A destructive force of high acceleration therefore is reduced to the form of a steady pressure.

Applications of these absorbers include war equipment where shock loads are particularly violent, as well as more prosaic machines such as steam hammers, high-speed motor generators, machine tools, electric typewriters, etc. Inasmuch as these absorbers are as incompressible as a solid block of metal, they do not permit relative movement of the mounted equipment, hence are particularly well adapted to building into machines. For example, they have been applied under the sow block of steam hammers to cushion the impact and isolate it from the machine frame.

This article and the preceding one have been concerned primarily with the reduction of vibration and noise through isolation and absorption. Because even the best mountings and absorbent materials take out only a percentage—albeit a high percentage—of vibration and noise, it is necessary also to do everything possible toward the elimination of vibration sources. Part IV of this article series will deal with the basic principles covering the determination of unbalanced force magnitudes and their reduction through the use of counterweighting.

Machine Design acknowledges with appreciation the cooperation of the following in the preparation of this article: American Felt Co.; Armstrong Cork Co.; Chamberlain Laboratories; Cork Import Corp.; Felters Co. Inc. (*Figs.* 26, 28, 31 and 32); The Felt Assn. (*Figs.* 27, 34 and 35); The Korfund Co. Inc.; United Cork Companies; United States Rubber Co. (*Fig.* 29); Western Felt Works (*Figs.* 30 and 33).

Specifying Intermediate Components for Machine Drives

By Richard K. Lotz

Part III—Couplings

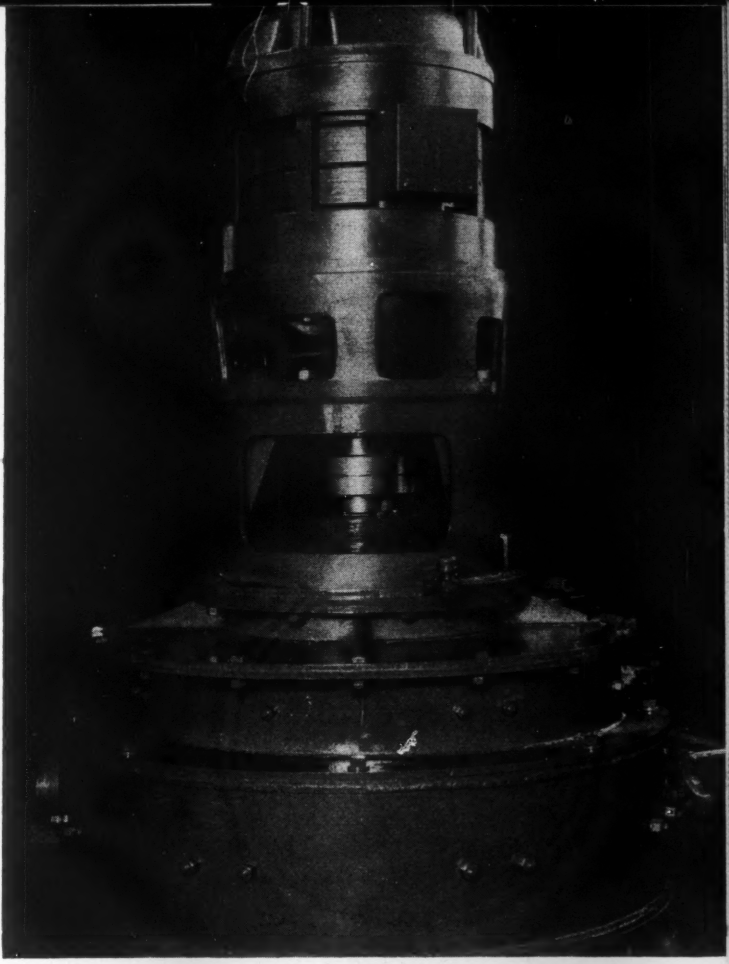
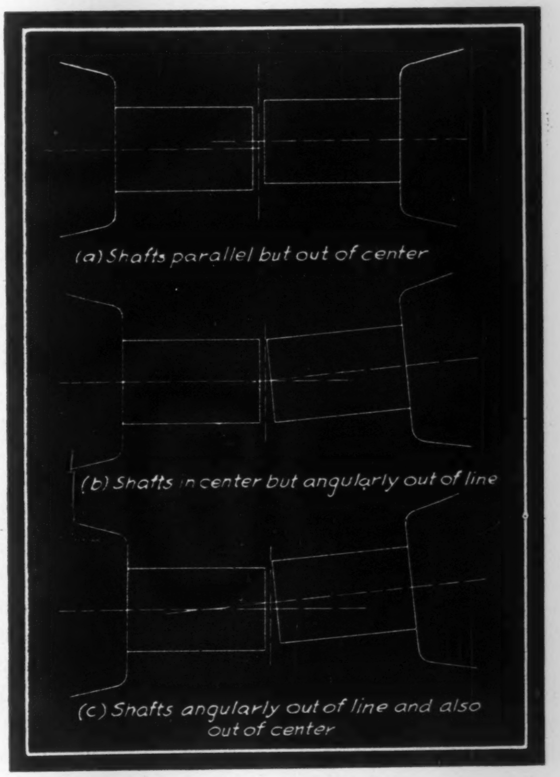


Fig. 1—Above—Rubber-bushed type of heavy-duty resilient alignment coupling used to connect a thirty-horsepower motor to a coal pulverizer

Fig. 2—Below—Three possible types of shaft misalignment for which flexible couplings must compensate. Type at c is combination of first two



(a) Shafts parallel but out of center

(b) Shafts in center but angularly out of line

(c) Shafts angularly out of line and also out of center

If it were possible to effect and permanently maintain perfect alignment of the shafts of two direct-connected mechanisms, rigid couplings would take care of all such connection requirements except those demanding shock absorption. However, even with the most exacting precision exercised in establishing original settings, development of subsequent misalignment rarely can be avoided. Foundations settle, bearings wear, temperature changes cause expansion and contraction, and loading of shafts within the individual machines gives rise to shaft deflection. Thus, "alignment" or "flexible" couplings must be used if maximum life of the coupled mechanisms is to be realized.

There are three specific kinds of shaft misalignment. These, as shown in views *a*, *b* and *c* of *Fig.* 2, are:

1. Shafts parallel but out of center
2. Shafts in center but angularly out of line
3. Shafts angularly out of line and out of center.

It generally is recognized that one of the worst forms of fatigue-inducing stressing is that in which complete reversal of imposed bending stresses takes place at frequent intervals. This is precisely the kind of stressing which occurs when misaligned, rotating shafts are rigidly coupled, and it should be added that not a great deal of misalignment is necessary to develop such stressing and subsequent fatigue.

Just what happens when misaligned, rigidly coupled shafts are rotated is clearly indicated in *Fig.* 3. With the shafts in the position shown, tensile stresses are created at *a* and *a'*, and compressive stresses are set up at *b* and *b'*. These stresses reverse com-

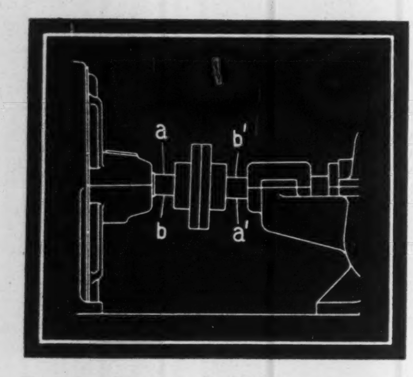


Fig. 3—Above—Indicating tension and compression stresses set up in rigidly connected shafts. Stresses reverse during each revolution

Fig. 4—Below—During operation, all teeth at both ends of this gear-type coupling are immersed in oil

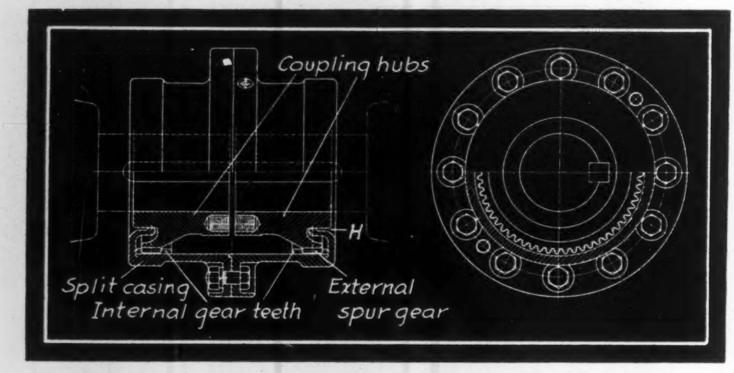
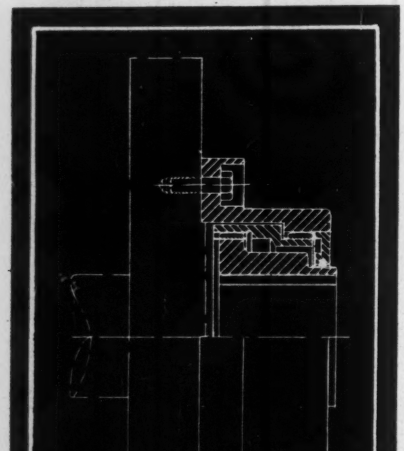


Fig. 5—Right—Three views show how gear-type coupling, such as that pictured in Fig. 4, compensates for various shaft misalignments

Fig. 6—Below—How an adaptation of the gear-type coupling of Fig. 4 saves space where connection direct to flywheel is required

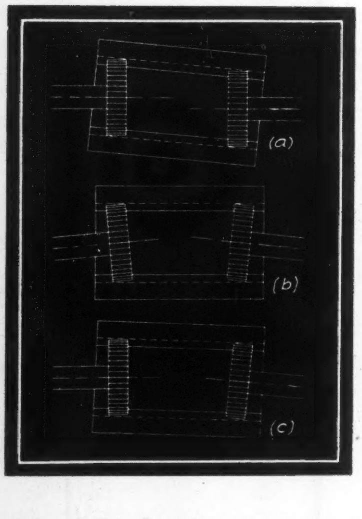


pletely during each revolution of the shafts. Such a condition not only subjects the shafts to excessive fatigue, but also overloads one or more of the shaft bearings, often causing them to run hot or fail completely.

In most cases any coupling which will permit shaft misalignment is referred to as a "flexible" coupling and the term has become somewhat generic. However, to be entirely accurate, recognition should be given to the fact that there are two broad classes of such couplings: Those in which all members are rigid and those employing members which are flexible or resilient. In the first class misalignment compensation is achieved by sliding fits between the rigid members, while in the latter, deformation of the flexible or resilient member or members permits misalignment. Thus a name more suitable for the first class might be "alignment" couplings, and the second class might more appropriately be referred to as "flexible alignment" or "resilient alignment" couplings.

A successful and popular type of alignment coupling is that pictured in *Fig.* 4, with the principle upon which it works demonstrated by the three views in *Fig.* 5. Referring to *Fig.* 4, the unit consists essentially of two hubs and a split casing. Each hub is keyed to its respective shaft and carries generated external spur gear teeth cut at a maximum distance from the shaft end. The split-casing halves carry generated internal gear teeth on their bores at the ends opposite their flanges. Coupling is effected through the mesh established by the internal and external gear teeth and it is the slight clearance existing in this mesh which permits misalignment of the shafts.

It might seem that considerable friction—with consequent wear—would exist between the internal and external gear teeth of such a coupling during rotation due to the continuous sliding action involved. Such, however, is not the case because the inner chamber is filled with oil, when the unit is stationary, up to the level indicated by *H* on the drawing. As the shafts are brought up to speed, centrifugal force distributes the oil so that all gear teeth are continuously immersed under pressure and metal to metal contact is obviated.



Many Adaptations Available

There are on the market many couplings which are adaptations of this principle and they can be obtained in sizes ranging from light to extremely heavy duty. One such adaptation is the unit pictured in *Fig.* 6. Specifically intended for connecting a shaft direct to a flywheel (as shown in drawing), brake drum or flange, it provides complete flexibility with approximately one-half the axial clearance required for couplings such as that shown in *Fig.* 4. It does not require dummy, pilot or stub shafts usually needed with other types of couplings.

As has been noted, the operating principle of this coupling is identical to that utilized in the coupling shown in *Fig.* 4. In this case, however, compensation for misalignment is made by an internal sleeve floating between an externally geared hub and an internally geared cover sleeve. The internal sleeve, engaging hub and outer sleeve, is free to slide and rock, effecting the necessary adjustments for differences in alignment. Like the coupling of *Fig.* 4, it employs oil to prevent wear and to cushion shock. As will be apparent, both the couplings of *Figs.* 4 and 6 will permit free lateral (endwise) movement of one or both coupled units.

Another type of alignment coupling is that pictured in the phantom view of *Fig.* 8. Here again all members of the coupling are rigid and alignment compensation is effected by sliding action between the parts. The principle of operation, however, is different than that used in the two couplings already discussed.

It will be seen that the two jaw flanges can slide and tilt in two planes displaced at right angles to each other. Just as a universal joint compensates for angular shaft misalignment by virtue of its ability to tilt in planes displaced at right angles, so does this coupling effect angular compensation. There are important differences however. First, the "tilting" action in a universal joint actually is a pivoting action occurring on definite pivot pins or studs, whereas the tilting of the two jaw flanges of this coupling is accomplished by their sliding and rocking on the center block member. Secondly, this coupling will compensate for "off-center" shaft misalignment because its members can slide radially in its two tilting planes.

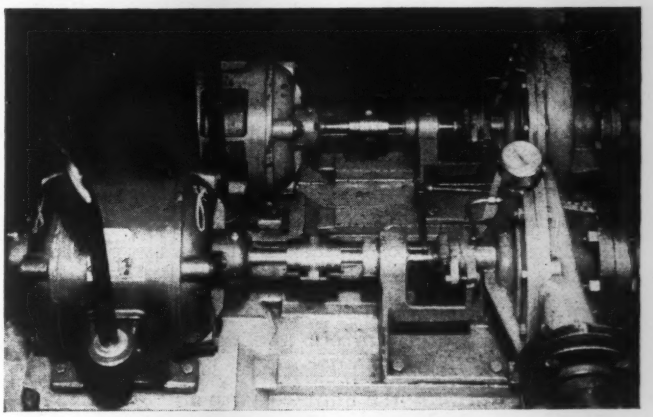


Fig. 7—Above—Two alignment couplings are employed to connect the shafts of motors and pumping units for circulating quenching oil in heat-treating system

Utilizes Replaceable Bearing Strips

Using only three primary members—two jaw flanges and one center block—the design of this coupling is extremely simple. An added feature is the replaceability of the four bearing strips shown secured to the four sides of the center block. After long periods of rigorous service, these strips can be removed and replaced by first taking out the screws through the access holes in the jaw flanges, sliding replacement strips into place without disturbing either of the connected machines or the coupling, and fastening the replacements securely into position. Two such couplings are shown in a typical application in *Fig.* 7.

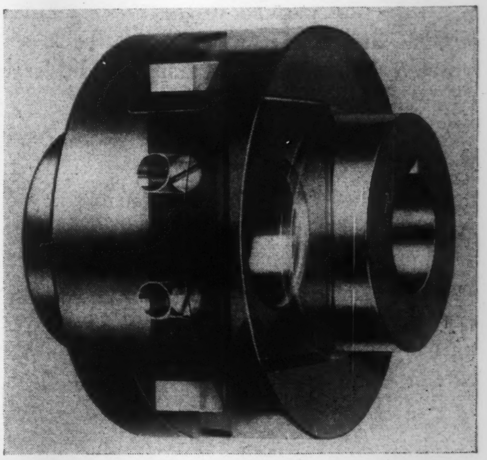


Fig. 8—Right—Bearing strips fastened to the sides of the center block in this alignment coupling are inserts and can be replaced without disturbing connected shafts or unit itself

The time-proved Oldham coupling is shown in *Fig.* 9. In this, the tongues of the centerpiece are positioned at right angles to each other and are sliding fits in the grooves of the two hubs. Fundamentally its ability to compensate, particularly for shafts which are parallel but not colinear, is due to the same operating principle used in the coupling of *Fig.* 8.

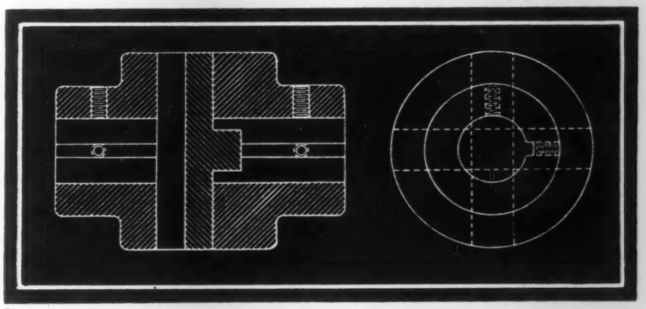


Fig. 9—Above—In Oldham coupling, tongues of center member are displaced at right angles, permitting off-center and angular misalignment

Considerably different in design and operating principle than the foregoing units is the chain-type coupling of *Fig.* 10. It consists of two cut-tooth sprocket wheels connected by a piece of steel roller chain which uses patented divided rollers and completely encircles the sprocket wheels. Within its limits, this coupling offers complete misalignment compensation and can be obtained in a variety of forms other than the enclosed type shown to meet specific application requirements.

Again exemplifying utter simplicity of design plus sturdy construction is the alignment coupling illustrated in *Fig.* 11. The center block employed in this unit is made of laminated phenolic of the same texture used in making nonmetallic pinions and gears, and its sliding surfaces are wick-lubricated from an oil reservoir contained within the block. This unit utilizes somewhat the same principle employed in the Oldham coupling and compensates fully for all types of shaft misalignment normally encountered.

A problem which has intrigued designers for many years is that posed by the requirements of a really simple and reliable overload release coupling. Many schemes have been tried from time to time, some successful, others disappointing failures. Perhaps one of the biggest stumbling blocks has been due to the ratchet or detent-type action usually employed. When no provision is made for keeping the pawls, detent pins or balls continuously out of en-

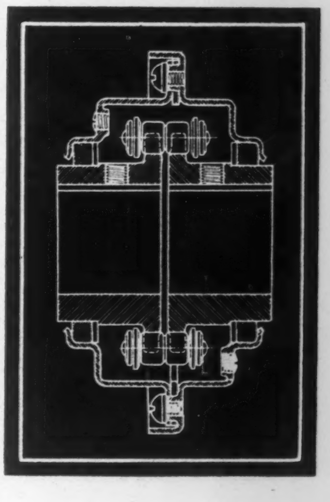


Fig. 10 — Right — Chain type coupling comprises essentially two sprocket wheels enveloped by roller chain; owes much of misalignment compensating ability to the divided rollers employed

gagement after overload torque has been imposed, the unit becomes not only noisy but subject to considerable wear.

An ingenious solution of this problem, at least where the speed of the coupled shafts exceeds 800 revolutions per minute, is shown in the unit pictured in *Fig.* 12. Like many other overload-release couplings, it works on the aforementioned detent principle. That is to say, the six balls used for establishing coupling between the inner and outer sleeves, do so because they are urged by springs into grooves in one member while being confined to only radial movement by grooves in the other member. The walls of the grooves which are cut into the periphery of the inner sleeve are sloped. Thus, the large balls will be urged out of them by the imposed torque.

With the coupling fully engaged (as shown) the angle of a line struck through the centers of the large and small balls with reference to the longitudinal axis of the unit is 45 degrees. Therefore, precluding the influence of friction and centrifugal force, the force exerted by the springs in a direction parallel to the unit's longitudinal axis will produce the same magnitude of force in a radial direction (toward the center of the unit) on the large balls.

Coupling Disengages Abruptly

When the torque being transmitted by this coupling reaches disengagement magnitude, the large balls will be flung out of their seats in the grooves of the inner sleeve. The disengagement will be abrupt, not gradual. This is because the radial component of the force exerted by the springs on the large balls will, once the balls have started moving out, decrease in proportion to the tangent of the angle made by the large and small balls with reference to the unit's longitudinal axis. In addition, it will of course be recognized that the force exerted by the springs will increase as they are compressed. Here again friction and centrifugal force have been precluded.

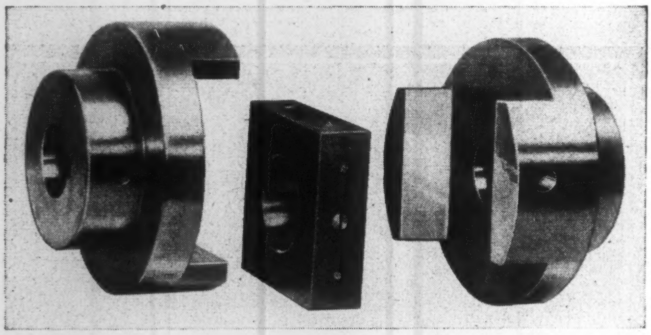


Fig. 11—Above—Nonmetallic center block of this coupling is wick-lubricated from self-contained reservoir

Fig. 12—Below—Large balls of this overload-release or "safety" coupling disengage with grooves of inner sleeve when excessive torque is imposed on coupled shafts

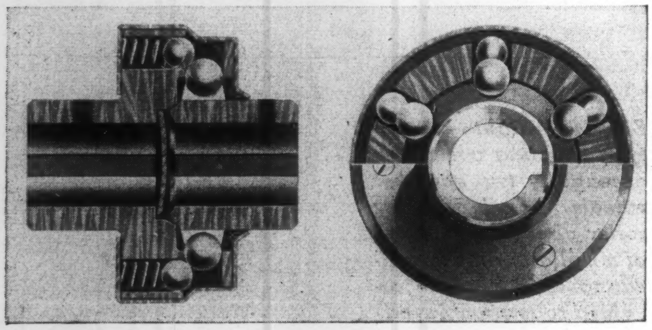


Fig. 13 — Right — Flexibility of laminated steel disks permits angular misalignment with this coupling

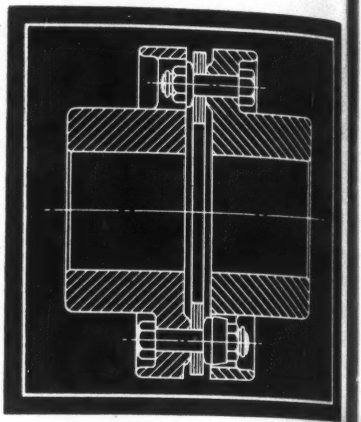
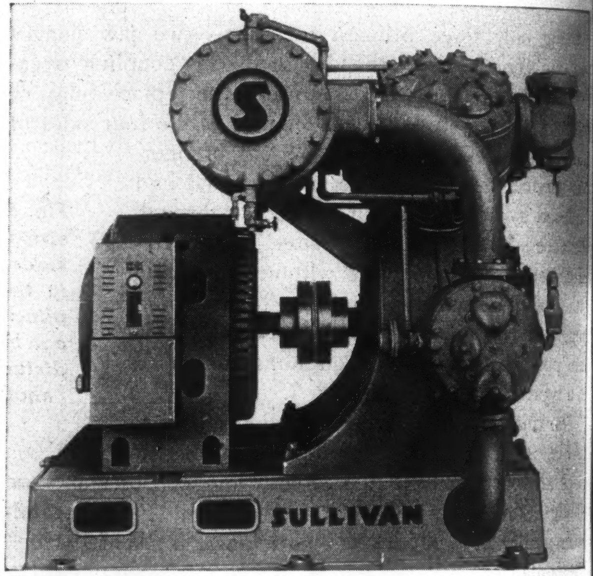


Fig. 14—Below—Application of above coupling in which one of connected units uses only one shaft bearing



Since the large balls must re-engage, it will be apparent that the angle made by the balls cannot be permitted to drop to zero. Actually an angle of about seven degrees is maintained at full engagement.

Of course centrifugal force helps to keep the large balls either clear of or in only light contact with the inner sleeve during full disengagement. Even at slow speeds, where centrifugal force has little effect, the meager angle of the balls results in a radial pressure on the inner sleeve of but small magnitude.

All of the couplings thus far discussed, with the exception of the overload-release unit, are of the alignment type and employ individual members which are for all practical purposes rigid. The use of flexible or resilient parts in couplings results in radical departures from the foregoing in operating principles, designs and constructions. These are the units referred to in the beginning of this article as flexible or resilient alignment couplings.

Pictured in the cross-sectional drawing of *Fig.* 13 is a type of resilient alignment coupling which has proved to be efficient and reliable in the solution of drive problems during the past three decades. Briefly it comprises two

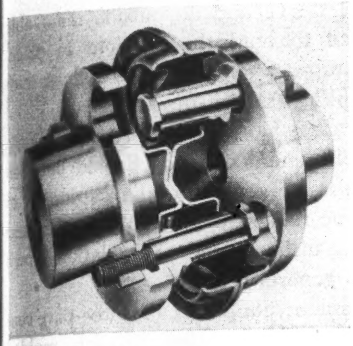


Fig. 15 — Left — Shaft vibrations are absorbed by rubber bushings of his coupling

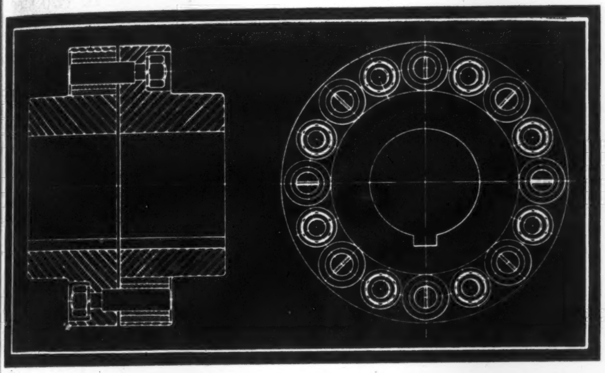


Fig. 16—Above—This rubber-bushed coupling uses graphite - impregnated hard bronze bearings

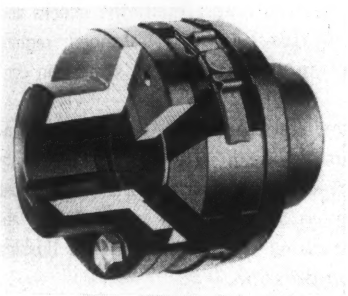


Fig. 17 — Left — Floating cushions of this coupling can readily be replaced

flanged hubs and a stack of laminated heat-treated steel disks fastened alternately to the hub flanges by a number of special bolts and nuts equally spaced about the diameter. The coupling shown in the illustration contains only one stack of disks and is intended specifically for applications wherein only angular misalignment takes place and the coupling must support weight. Thus it is suited particularly for coupling machines the shafts of which employ but one bearing. For example, it has been used successfully on diesel locomotives. In these the generator has only one bearing and one-half the weight of the armature is carried by the coupling, which connects to the end bearing of the engine. Concentricity of the armature shaft is maintained and only angular misalignment is encountered. An application of similar nature is shown in *Fig.* 14.

What Two-Stack Models Offer

Other models of this type coupling employ not one but two stacks of steel disks and these are separated by a center member. The disks are bolted alternately to both the two end hubs and the center member with the result that linear or off-center misalignment is compensated for as well as angular misalignment. Units of this type are free of backlash, require no lubrication and offer long trouble-free life. To prevent stress concentrations at the clamping faces when the disks are being flexed during shaft misalignment, the faces are beveled as shown in *Fig.* 13.

Absorbing Vibrations

It should be added at this juncture that destructive vibrations often are set up within mechanisms and can, unless some method of absorption is employed, be transmitted from one machine to another through the connected shafts. Resilient couplings, when properly applied, can absorb such vibrations and prevent their transmission from mechanism to mechanism. One of the couplings specifically designed to absorb vibrations is that pictured in *Fig.* 15. It consists of two steel hub members and a floating center-unit assembly to which each hub is separately connected. The center unit comprises a two-piece, riveted, pressed-steel housing in which are assembled, under pressure, four resilient rubber trunnion bushings located 90 degrees apart. Each of the molded bushings is provided with an integral laminated wire-screen bushing

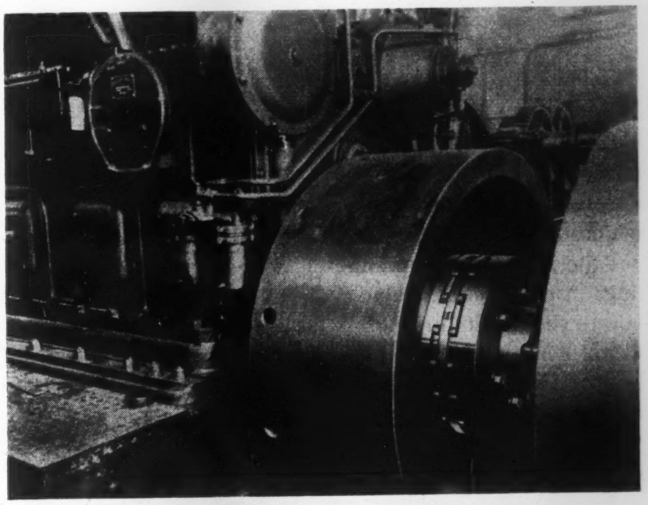
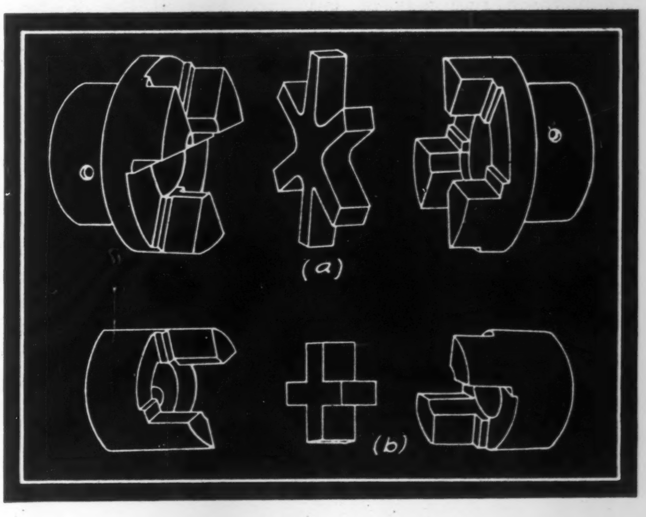


Fig. 18—Above—Floating-cushion type coupling provides flexibility of connection in large diesel installation

Fig. 19—Below—These resilient alignment couplings employ only three parts: Two jawed hubs and one rubber insert



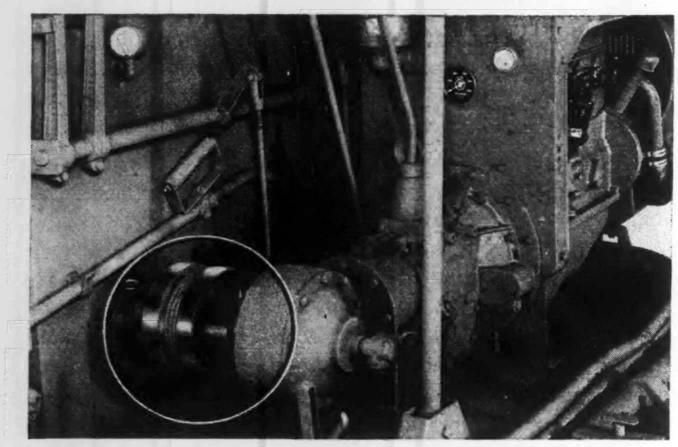


Fig. 20—Disks of flexible alignment coupling used in this installation are built up of specially impregnated fabric

bonded to the bore. Also, solid steel bushings are pressed into the trunnions through which the connecting bolts of the hub members pass. The rubber bushings are encased with fabric rings impregnated with rubber which serve to support the shapes of the bushings. This coupling not only absorbs vibrations but also will compensate for all types of shaft misalignment.

Self-Lubricating Bearings Employed

Long life without the necessity of frequent servicing has been imparted in a simple and effective manner to the resilient alignment coupling pictured in *Fig.* 16 through the use of graphite-impregnated hard bronze bearings which obviate the need for additional lubrication throughout the life of the coupling. The steel studs of this coupling, fastened alternately to the two flanged hubs, are accurate sliding fits in the bronze bearings which are nested in resilient rubber bushings carried by the two flanged hubs. Cushioning of shocks and vibrations, as well as compensation for all types of shaft misalignment are offered by this coupling. It is shown in a typical application in *Fig.* 1.

Free-floating cushions are featured in the coupling shown in the cutaway view of *Fig.* 17. One set of steel jaws is part of the removable ring which is piloted on and fastened to the flanged hub at the left end of the unit. A similar set of jaws is part of the other flanged hub. Between these two sets of jaws are located the floating cushions which are obtainable in a number of different resilient materials to meet specific application requirements. An inside steel sleeve and an outside removable retaining band are used to hold the cushions in place. Compensating for vibrations and shocks as well as shaft misalignment, this coupling can be disconnected without moving the load-carrying cushions or steel retaining band. Relative rotational displacement can be effected between the two connected shafts by removing the capscrews of the coupling, turning one flange relative to the other and rebolting. The coupling utilized in the installation shown in *Fig.* 18 is one of this general type.

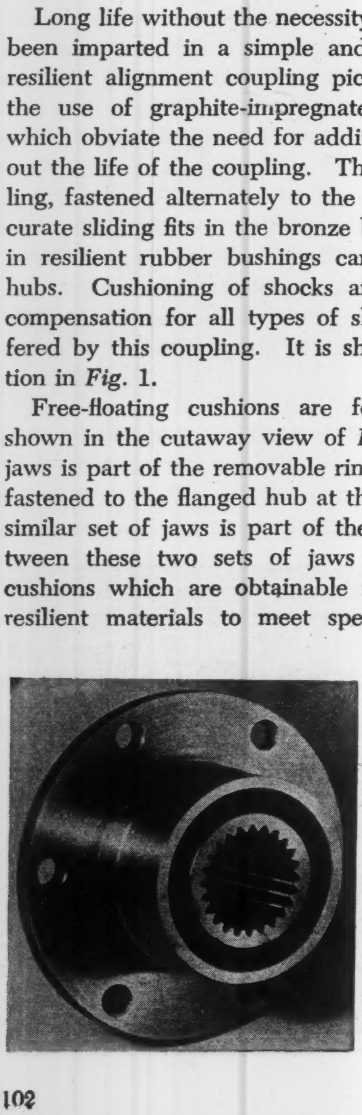


Fig. 21—Rubber bushing of this coupling is placed in shear by torsional shocks and vibrations. Unit also compensates for various types of shaft misalignment

Simple resilient alignment couplings of three-part construction are those shown in *Fig.* 19. In each, molded rubber cushions are nested between the jaws of two steel flanged mounting hubs. Where the six-armed cushion is employed in unidirectional drives loading will exist on only three of the arms. In similar applications using the four-armed cushion, loading is present on two arms. In either type, should the load-carrying arms become worn after long service they can be moved up one position, thereby putting into their place the other set of arms, formerly unloaded.

Operating on still another principle is the flexible alignment coupling shown in the installation of *Fig.* 20. In this unit three stacks of specially impregnated fabric disks are bolted alternately to the two flanged hubs at regular intervals on the diameter, and flexing of the disks compensates for shaft misalignment and cushions shocks and vibrations. Couplings of this type are balanced, require no lubrication, are quiet in operation and sturdy in construction.

One of the most recent developments in resilient alignment couplings is the unit shown in *Fig.* 21. Flexibility and cushioning is imparted by the rubber bushing located between the splined sleeve and flanged hub. When absorbing shocks and vibrations the rubber in the bushing is put into shear, not compression.

Manufacturer Should Have Complete Data

It will be apparent from all of the foregoing that few if any coupling problems cannot be solved through the use of readily available commercial couplings. However, it is well to bear in mind that no coupling manufacturer can recommend the best unit for a given application unless he is supplied with complete data pertaining to the installation. Thus, every effort should be made to furnish accurate information as to horsepower transmitted, speeds involved, maximum overloads anticipated, magnitude of shaft misalignment expected or known, character and nature of shocks and vibrations, space limitations, electrical insulation requirements, protection from grease, dirt and oil, and accessibility of the unit for installation.

MACHINE DESIGN acknowledges with appreciation the collaboration of the following companies in the preparation of this article: Ajax Flexible Coupling Co. (*Figs.* 1 and 16); American Flexible Coupling Co. (*Figs.* 7 and 8); The Bartlett Hayward Co. (*Figs.* 2, 3, 4 and 5); Charles Bond Co. (*Fig.* 19); Bushings, Inc. (*Fig.* 21); Certified Flexible Couplings; A. T. Dodge Co. (*Fig.* 12); Farrel-Birmingham Co. Inc. (*Fig.* 6); D. O. James Mfg. Co. (*Fig.* 11); Link-Belt Co. (*Figs.* 9 and 10); Lovejoy Flexible Coupling Co. (*Figs.* 17 and 18); Morse Chain Co. (*Fig.* 15); Poole Foundry & Machine Co.; The Smith Power Transmission Co. (*Fig.* 20); Thomas Flexible Coupling Co. (*Figs.* 13 and 14).

MACHINE *Editorial* DESIGN

Substitution for Civilian Production Now Confronts Designers!

GREAT credit is due the engineer for his handling of the problems of substitution and conservation of materials during the early days of the war. Ingenuity of the highest order was called for and applied to cope with the scarcities existing prior to the increased production of critical materials.

That particular phase of the materials situation is virtually ended, insofar as war materiel is concerned, as evidenced by the gradual easing of restrictions on materials and the allotment of certain basic types for the purpose of reconversion to production of civilian goods. Yet it is apparent that because of continued military requirements until the war with both Germany and Japan is won, similar ingenuity to that which was applied earlier will need to be exercised in the application of materials to specific uses.

Even though the supply of aluminum now exceeds the demand, and 100,000 tons of carbon steel as well as 25,000 tons of alloy steel have been allotted during the fourth quarter of this year to manufacturers of civilian goods, this is only a drop in the bucket as far as the over-all picture is concerned. Urgent need for substitution—though happily for a far different purpose—therefore will continue, and it will be up to the designer of machines to put forward every effort in the utilization of the most readily-available materials to help the reconversion program achieve its goal.

Publication of MACHINE DESIGN'S twelfth edition of its directory of materials as a supplement to the current issue of the magazine will, it is hoped, aid the designer considerably in reaching this objective. Adequately cross-indexed and greatly enlarged over previous editions, the directory should hold the key to the solution of many of the difficult materials problems that will confront engineers responsible for design of future machines.

L. E. Jermy

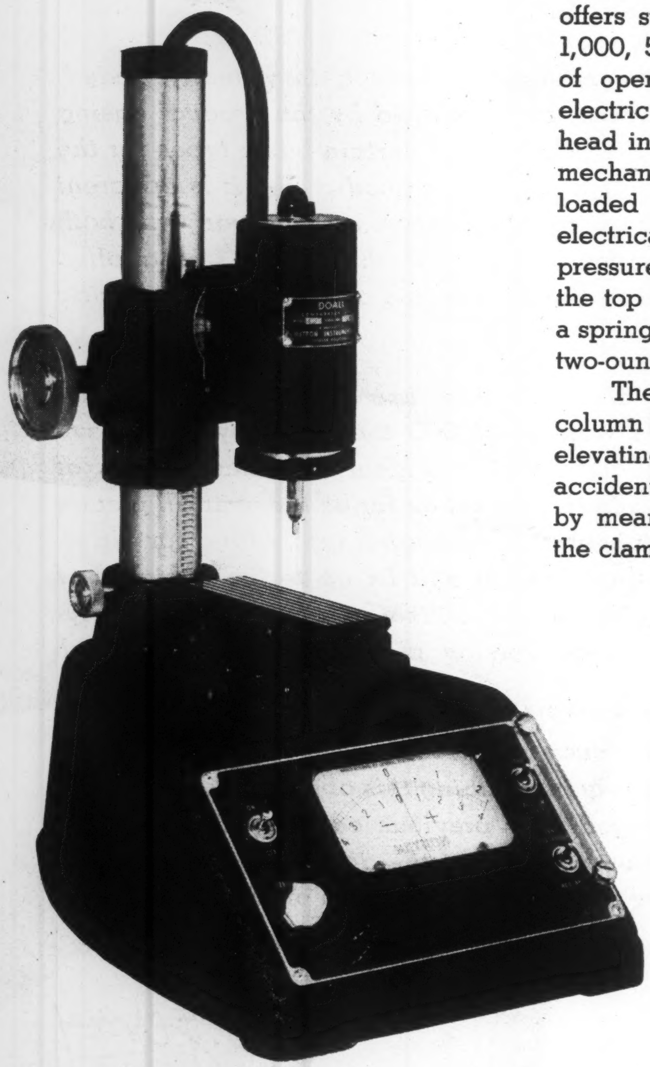
Outstanding Designs

Magnifying Comparator

Special electrical circuit of this precision instrument is such that minute motion of the gage spindle moves an armature arrangement to balance a symmetrical inductance bridge and produce height indication on the scale. Accuracy is unaffected by power variations because of the stabilizing circuit incorporated. Spindle of the head is supported in diaphragms, without sliding bearings. Thus no tendency exists for the spindle to bind even at lowest spindle pressures.

Designed and manufactured by the Metron Instrument Co., this comparator can be used to check tools, gages and machine parts in a tolerance range of from plus or minus .000001-inch to plus or minus .02-inch. It offers switch-controlled magnifications of 500, 1,000, 5,000 and 10,000 to one. Four ranges of operation are incorporated by means of electric switches, 360-degree swivelling of the head in vertical and horizontal planes, vernier mechanical adjustment by means of spring-loaded differential threads, and hairline electrical zero adjustment by rheostat. Spindle pressure is adjusted by a calibrated knob at the top of the head which controls the force of a spring from four ounces to thirty-six ounces in two-ounce steps.

The column bracket is locked firmly to the column by a handwheel on the side opposite the elevating handwheel. Residual drag to prevent accidental dropping of the head is obtained by means of simple spring-loading screws on the clamp.

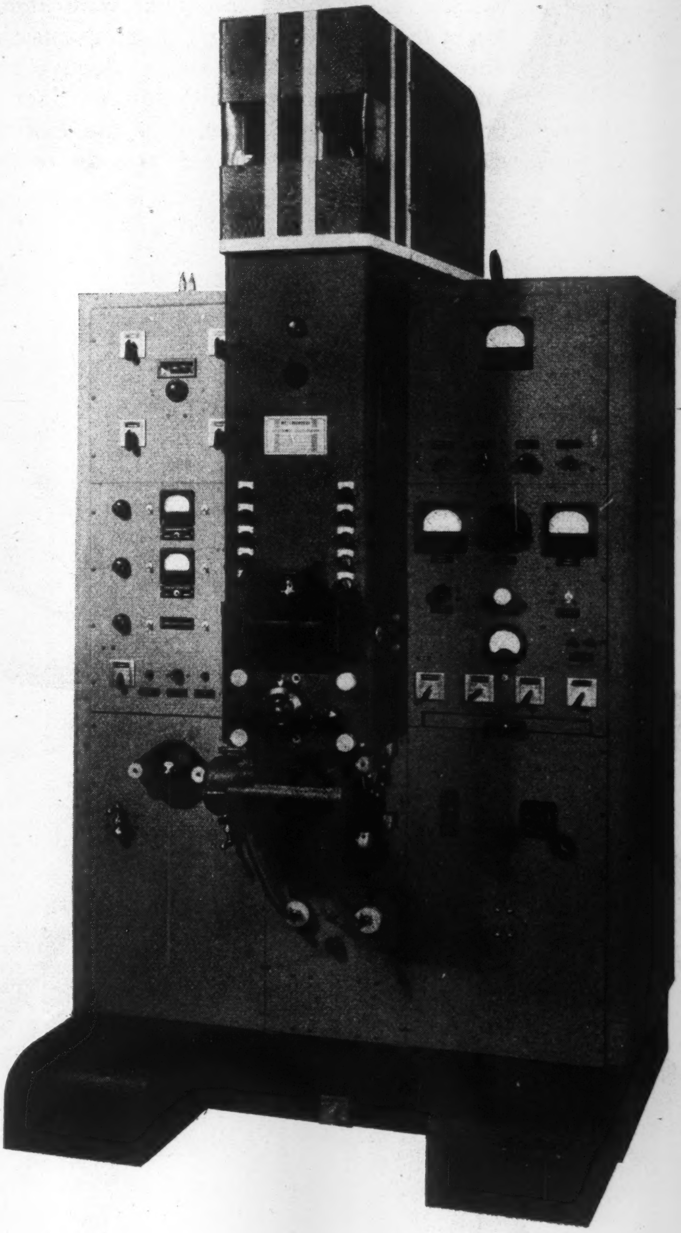


Electronic Oscillograph

This streamlined version of the cathode-ray oscillograph was developed to meet the requirements of the aircraft industry for an instrument able to analyze ignition-system phenomena lasting a fraction of a millionth of a second!

Cathode-ray tube, stationary and rotating film holders, 50-kilovolt rectifier unit and high-speed vacuum pump are all contained in a dead-front steel cubicle and constitute the main elements of this Westinghouse electronic unit. The electron beam, which is controlled by the electrical phenomena being recorded is generated in a cold cathode tube housed in the upper portion of the central section. A fluorescent screen for direct observation, a stationary film holder taking a standard No. 122 Kodak film and a rotating drum which holds a film five by eighteen inches, are housed in the central section directly below the cathode-ray tube. The stationary film is for recording electrical phenomena lasting one-thousandth of a second or less. For phenomena ranging from one-thousandth to one-tenth of a second the rotating drum is used.

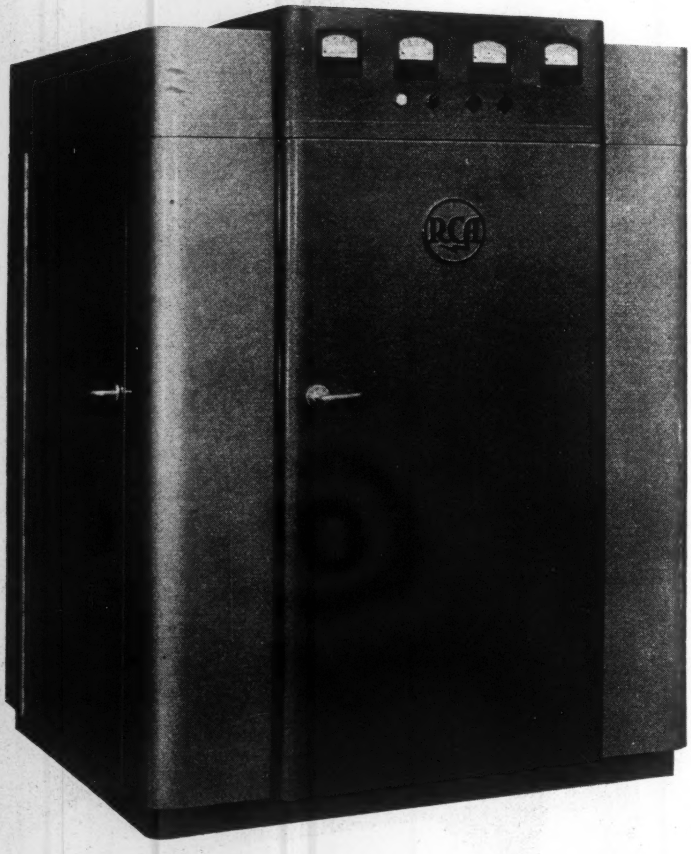
Both stationary and rotating films are mounted in a vacuum chamber where the electron beam will strike them directly to produce a sharp undistorted image. To permit rapid reloading of film, a vacuum pump is provided which reduces the pressure to a satisfactory working value within ten minutes.



Electronic Power Generator

High-frequency output of this power generator made by Radio Corporation of America is obtained from a stabilized, self-excited oscillator employing two heavy-duty air-cooled power tubes which are supplied with high voltage direct current by a three-phase, full-wave rectifier. Air-cooled power tubes are used to increase flexibility and reduce installation and maintenance costs by eliminating the motor, pump, radiator, tank and piping associated with water cooling. A built-in forced draft system insures proper cooling of the tubes.

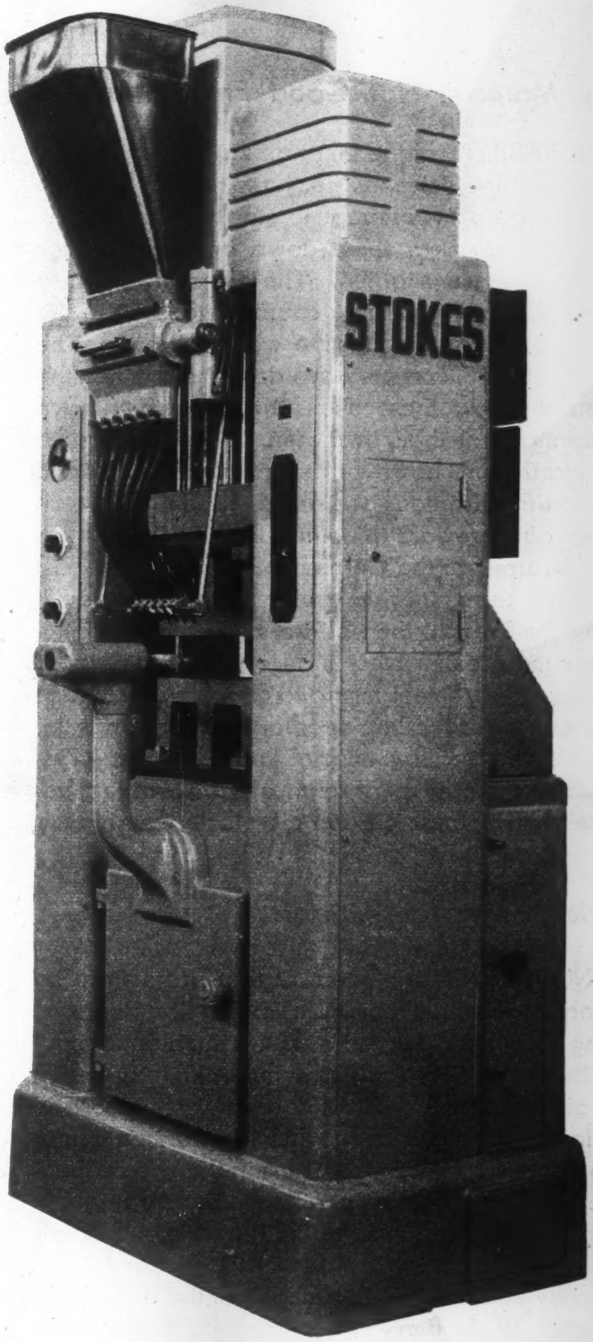
All tubes employed are of types which have given exceptionally good life in industrial and communication services during past years. Automatic protective relays guard the tubes from accidental damage. Four meters at the top of the unit provide an instantaneous check on operating conditions. Tuning and operating controls and protective relays are located on the front panel and protected by an outer hinged door. An auxiliary control unit provides complete operating control at the load location. Full-length doors on both sides of the main cabinet provide ready access to tubes and components. To safeguard operating personnel, the main unit has no exposed power terminals except an insulated connector protruding from the top for connection to the high-frequency transmission line. Door interlock switches automatically turn off the high-voltage power when either of the side doors is open. Another switch automatically grounds the high-voltage bus when either of the doors is open.



Automatic Plastics Molding Press

Here is an example of functional styling achieved without sacrifice of accessibility or efficiency and without increase of cost. Designed and manufactured by F. J. Stokes Machine Co. and styled by Van Doren, Nowland and Schladermundt, this completely automatic molding press employs a totally enclosed housing for sealing out abrasive plastic dust which ordinarily presents a serious problem in such equipment. The main frame is a semisteel casting with open-center construction, eliminating the use of side rods and offering easy access to the mold and all working parts. An air manifold and "push-off" are mounted on a swinging panel which, when closed, seals off the lower knockout mechanism.

Powered by a two-horsepower motor and variable delivery pump, the machine develops fifty tons pressure using a seven-inch diameter cylinder. This is accomplished through a seven-to-one ratio booster in the hydraulic circuit, requiring a maximum pump pressure of only 400 pounds. A highly sensitive trap or checking device weighs all parts as they are ejected. Should any part fail to eject, the press is automatically stopped and a warning bell is sounded. Another feature is a multiple feed with micrometer adjustments for capacities up to forty-eight cubic inches. All feed, ejection and knockout operations are accurately timed by a flush-mounted, bar type controller. An electrical timer is used for establishing length of cure and is independent of the main controller.



Design Roundup

Enemy Materiel Not Good Enough

VULNERABILITY of the German tanks to bazookas has forced the Germans to hang plates on the sides of tanks in an attempt to stop the projectiles. These plates do slow them down but only reduce their effectiveness slightly. The German infantry rocket shell, developed as a counter measure to the American one, proves effective when it works. The catch is that the Germans have developed a healthy aversion to firing these shells because they have killed so many of their own men. The German 88-mm antitank gun, however, is an effective weapon and still is rated among the enemy's best. German airplanes also are said to be excellent. With respect to other equipment the German half-track is the best of its kind used in this war. Originally developed by the French, the half-track is utilized by the Germans more extensively than by any other country. Using a cast-steel frame to which rubber pads are bolted, the track has needle roller bearings for the pins, protected by special rubber seals. This track gives splendid performance with a rolling resistance of 43 pounds per ton of vehicle weight.

Electric Power for Aircraft

TRANSOCEANIC air liners of the future may be powered by electric motors, allowing greater load carrying for longer distances with a substantial saving in fuel. An electric drive would eliminate much of the air resistance or drag caused by engine and propeller in the nose of the fuselage or, on multi-engine planes, by engine nacelles in the wings. Electric motors, being smaller, can be mounted entirely in the wing structure, thus offering little resistance to air flow. This prediction was made at the recent A.I.E.E. meeting by Lieut. Col. T. B. Holliday of the U. S. Army Air Forces, W. L. Berry of the Hughes Aircraft Co., and F. W. Godsey of Westinghouse. In present-day planes they say that drag of the engines may waste from 20 to 40 per cent of the horsepower output. With electric drive, the power plant consisting of high-speed engines and electric generator could be placed in the fuselage. This concentration of weight in the center of the plane would increase maneuverability and provide a convenient shock absorber—if used in warplanes—to withstand the recoil of heavy machine guns and cannon. With this type of drive it also would be possible to use pusher-type propellers instead of tractor type to give increased lift to the wings at high speeds and reduced turbulence of the slip stream over the wings. Chief disadvantage of the new system would result from increased weight and increased cost of the power plant. These could be offset by redesign to utilize the advantages inherent in the system.

Facilitate Mockup and Pattern Making

WAR HAS INTENSIFIED the need for speed, accuracy and extensive contouring of models and patterns. Result is that pattern shops have been searching for improved materials and methods to fulfill these demands. Experience recently has shown that complex contours and intersections can be developed with gypsum cements and that patterns or models made from them retain their accuracy of dimension under varying temperature and humidity conditions. Among other advantages gained through use of these cements are flexibility of design in making complicated mock-ups and check fixtures, saving in patternmaking time, and ease of producing sectional dies from full-scale mock-ups.

Proposes Combined Engineering Society

BECAUSE THE ENGINEER has "something different to sell than the machinist, the clerk or the laborer" a nationwide association of engineers, embracing all branches of that profession, is advocated by C. A. Powel, newly elected president of A.I.E.E. He says there is urgent need for an all-inclusive organization that can speak for engineers in the councils of government and the ranks of industry. Such an association would be devoted specifically to the welfare of the profession as a whole as well as to that of the individual members.

Hardness Conversion Tables

BECAUSE numerous different hardness scales are in general use, it often is difficult to compare the relative hardnesses of metals which have been tested with different measuring devices. To aid the designer in making such comparisons, the conversion tables are presented in this data sheet, together with a brief discussion of indentation hardness tests and the limitations of conversion values. The tables and accompanying comments[1] are based on a symposium held under the auspices of the American Society for Testing Materials

IT IS generally accepted that the term hardness has an extremely vague meaning since this may be used to designate a number of distinct material characteristics. The expressions "indentation hardness", "cutting hardness", or "abrasion hardness" are frequently used but each covers quite distinct and separate properties. When the engineer uses the term hardness it is commonly understood that reference is being made to "indentation hardness".

The indentation test, as is well known, is merely a relative test since the stresses caused by the indentation are unknown and are likely to remain so. The results obtained from such a test can, however, be interpreted, and this has been of great value in the control of materials. In this respect the test possibly occupies a similar place to that of the impact test as being arbitrary but nevertheless extremely useful.

As developed by Brinell the indentation hardness, H, is defined as the unit pressure produced by a load of 3000 kilograms through a ball of 10-millimeter diameter, the pressure being based on the spherical area rather than the projected area of the resulting indentation. Thus

$$H=\frac{P}{\frac{\pi D}{2}\left(D-\sqrt{D^2-d^2}\right)}$$

where $H=$ indentation hardness or brinell number, $P=$ load in kilograms, $D=$ diameter of ball in millimeters, and $d=$ diameter of impression in millimeters.

The brinell instrument is an old, trustworthy device for measuring hardness and is still widely used in commercial plants. For measuring very hard substances there are specially hardened steel balls such as Hultgren's extra-hard steel balls, special tungsten-carbide balls, and hemispherical diamond indenters.

Instead of the spherical indenter ordinarily used on the brinell machine, a diamond pyramid indenter with a 136-degree angle between opposite faces may be used. The machine may then serve as a vickers pyramid hardness tester. Instead of measuring the diameter of the spherical indentation, the diagonal of the square indentation is measured.

The rockwell hardness measuring device has attained an enviable reputation because of its speed, accuracy and wide range of adaptability. While Brinell based his tests on the diameter of the indentation made by a steel ball or a diamond hemisphere, Rockwell based his on the depth of the indentation of the spherical penetrator. This latter procedure increases the speed because a dial indicator can be attached for measuring the depth directly, and does not require the separate indentation measuring process in the case of the brinell instrument.

If the relation between depth of indentation and hardness holds, that is, if the law of similarity holds, then a wide range of hardness testing may be set up by varying both the size of the ball and the major load employed, TABLE I. The rockwell instrument has 15 or more ranges of scales for hardness testing. It is essential in giving hardness numbers that the scale symbol

TABLE I

Hardness Scale Test Conditions

Scale	Load	Penetrator
Rockwell B	100 kg	$\frac{1}{16}$-in. ball
Rockwell F	60 kg	$\frac{1}{16}$-in. ball
Rockwell G	150 kg	$\frac{1}{16}$-in. ball
Rockwell E	100 kg	⅛-in. ball
Rockwell H	60 kg	⅛-in. ball
Rockwell K	150 kg	⅛-in. ball
Rockwell C	150 kg	Brale
Rockwell A	60 kg	Brale
Rockwell D	100 kg	Brale
Rockwell Superficial 15-T*	15 kg	$\frac{1}{16}$-in. ball
Rockwell Superficial 30-T*	30 kg	$\frac{1}{16}$-in. ball
Rockwell Superficial 45-T*	45 kg	$\frac{1}{16}$-in. ball
Rockwell Superficial 15-N*	15 kg	N Brale
Rockwell Superficial 30-N*	30 kg	N Brale
Rockwell Superficial 45-N*	45 kg	N Brale
Brinell Standard 500-kg load	500 kg	10-mm ball
Brinell Standard 3000-kg load	3000 kg	10-mm ball
Diamond Pyramid	10 kg	4-sided 136-deg. diamond pyramid

*Rockwell Superficial hardness tester has lighter loads and more sensitive depth-reading system and is used where the indentation must be exceptionally shallow.

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[1] Contributors to the symposium included J. M. Lessells, Massachusetts Institute of Technology; S. R. Williams, Amherst College; and S. L. Hoyt, Battelle Memorial Institute.

TABLE II

For Unhardened Steel, Steel of Soft Temper, Gray and Malleable Cast Iron and Most Nonferrous Metal

Rockwell Hardness Tester						Rockwell Superficial			Brinell		Tensile Strength
B scale	F scale	G scale	E scale	K scale	A scale	15-T scale	30-T scale	45-T scale	Standard 500-kg. Load	Standard 3000-kg. Load	Thousand psi.
100	....	82.5	....	....	61.5	93.0	82.0	72.0	201	240	116
99	....	81.0	....	....	61.0	92.5	81.5	71.0	195	234	112
98	....	79.0	....	....	60.0	....	81.0	70.0	189	228	109
97	....	77.5	....	....	59.5	92.0	80.5	69.0	184	222	106
96	....	76.0	....	....	59.0	....	80.0	68.0	179	216	103
95	....	74.0	....	....	58.0	91.5	79.0	67.0	175	210	101
94	....	72.5	....	....	57.5	....	78.5	66.0	171	205	98
93	....	71.0	....	....	57.0	91.0	78.0	65.5	167	200	96
92	....	69.0	....	100	56.5	90.5	77.5	64.5	163	195	93
91	....	67.5	....	99.5	56.0	....	77.0	73.5	160	190	91
90	....	66.0	....	98.5	55.5	90.0	76.0	62.5	157	185	89
89	....	64.0	....	98.0	55.0	89.5	75.5	61.5	154	180	87
88	....	62.5	....	97.0	54.0	....	75.0	60.5	151	176	85
87	....	61.0	....	96.5	53.5	89.0	74.5	59.5	148	172	83
86	....	59.0	....	95.5	53.0	88.5	74.0	58.5	145	169	81
85	....	57.5	....	94.5	52.5	....	73.5	58.0	142	165	80
84	....	56.0	....	94.0	52.0	88.0	73.0	57.0	140	162	78
83	....	54.0	....	93.0	51.0	87.5	72.0	56.0	137	159	77
82	....	52.5	....	92.0	50.5	....	71.5	55.0	135	156	75
81	....	51.0	....	91.0	50.0	87.0	71.0	54.0	133	153	74
80	....	49.0	....	90.5	49.5	86.5	70.0	53.0	130	150	72
79	....	47.5	....	89.5	49.0	....	69.5	52.0	128	147	..
78	....	46.0	....	88.5	48.5	86.0	69.0	51.0	126	144	..
77	....	44.0	....	88.0	48.0	85.5	68.0	50.0	124	141	..
76	....	42.5	....	87.0	47.0	....	67.5	49.0	122	139	..
75	99.5	41.0	....	86.0	46.5	85.0	67.0	48.5	120	137	..
74	99.0	39.0	....	85.0	46.0	....	66.0	47.5	118	135	..
73	98.5	37.5	....	84.5	45.5	84.5	65.5	46.5	116	132	..
72	98.0	36.0	....	83.5	45.0	84.0	65.0	45.5	114	130	..
71	97.5	34.5	100	82.5	44.5	....	64.0	44.5	112	127	..
70	97.0	32.5	99.5	81.5	44.0	83.5	63.5	43.5	110	125	..
69	96.0	31.0	99.0	81.0	43.5	83.0	62.5	42.5	109	123	..
68	95.5	29.5	98.0	80.0	43.0	....	62.0	41.5	107	121	..
67	95.0	28.0	97.5	79.0	42.5	82.5	61.5	40.5	106	119	..
66	94.5	26.5	97.0	78.0	42.0	82.0	60.5	39.5	104	117	..
65	94.0	25.0	96.0	77.5	....	....	60.0	38.5	102	116	..
64	93.5	23.5	95.5	76.5	41.5	81.5	59.5	37.5	101	114	..
63	93.0	22.0	95.0	75.5	41.0	81.0	58.5	36.5	99	112	..
62	92.0	20.5	94.5	74.5	40.5	....	58.0	35.5	98	110	..
61	91.5	19.0	93.5	74.0	40.0	80.5	57.0	34.5	96	108	..
60	91.0	17.5	93.0	73.0	39.5	....	56.5	33.5	95	107	..
59	90.5	16.0	92.5	72.0	39.0	80.0	56.0	32.0	94	106	..
58	90.0	14.5	92.0	71.0	38.5	79.5	55.0	31.0	92	104	..
57	89.5	13.0	91.0	70.5	38.0	....	54.5	30.0	91	103	..
56	89.0	11.5	90.5	69.5	....	79.0	54.0	29.0	90	101	..
55	88.0	10.0	90.0	68.5	37.5	78.5	53.0	28.0	89	100	..
54	87.5	8.5	89.5	68.0	37.0	....	52.5	27.0	87	...	..
53	87.0	7.0	89.0	67.0	36.5	78.0	51.5	26.0	86	...	..
52	86.5	5.5	88.0	66.0	36.0	77.5	51.0	25.0	85	...	..
51	86.0	4.0	87.5	65.0	35.5	....	50.5	24.0	84	...	..
50	85.5	2.5	87.0	64.5	35.0	77.0	49.5	23.0	83	...	..

Rockwell Hardness Tester							Rockwell Superficial			Brinell
B scale	F scale	G scale	E scale	H scale	K scale	A scale	15-T scale	30-T scale	45-T scale	Standard 500-kg. Load
50	85.5	2.5	87.0	....	64.5	35.0	77.0	49.5	23.0	83
49	85.0	1.0	86.5	....	63.5	....	76.5	49.0	22.0	82
48	84.5	...	85.0	....	62.5	34.5	....	48.5	20.5	81
47	84.0	...	85.0	....	61.5	34.0	76.0	47.5	19.5	80
46	83.0	...	84.5	....	61.0	33.5	75.5	47.0	18.5	..
45	82.5	...	84.0	....	60.0	33.0	....	46.0	17.5	79
44	82.0	...	83.5	....	59.0	32.5	75.0	45.5	16.5	78
43	81.5	...	82.5	....	58.0	32.0	74.5	45.0	15.5	77
42	81.0	...	82.0	....	57.5	31.5	....	44.0	14.5	76
41	80.5	...	81.5	....	56.5	31.0	74.0	43.5	13.5	75
40	79.5	...	81.0	....	55.5	....	73.5	43.0	12.5	..
39	79.0	...	80.0	....	54.5	30.5	....	42.0	11.0	74
38	78.5	...	79.5	....	54.0	30.0	73.0	41.5	10.0	73
37	78.0	...	79.0	....	53.0	29.5	72.5	40.5	9.0	72
36	77.5	...	78.5	100	52.0	29.0	....	40.0	8.0	..
35	77.0	...	78.0	99.5	51.5	28.5	72.0	39.5	7.0	71
34	76.5	...	77.0	99.0	50.5	28.0	71.5	38.5	6.0	70
33	75.5	...	76.5	....	49.5	....	....	38.0	5.0	69
32	75.0	...	76.0	98.5	48.5	27.5	71.0	37.5	4.0	..
31	74.5	...	75.5	98.0	48.0	27.0	....	36.5	3.0	68
30	74.0	...	75.0	....	47.0	26.5	70.5	36.0	2.0	67
29	73.5	...	74.0	97.5	46.0	26.0	70.0	35.5	1.0	..
28	73.0	...	73.5	97.0	45.0	25.5	....	34.5	...	66
27	72.5	...	73.0	96.5	44.5	25.0	69.5	34.0	...	..
26	72.0	...	72.5	....	43.5	24.5	69.0	33.0	...	65
25	71.0	...	72.0	96.0	42.5	....	....	32.5	...	64
24	70.5	...	71.0	95.5	41.5	24.0	68.5	32.0	...	..
23	70.0	...	70.5	....	41.0	23.5	68.0	31.0	...	63
22	69.5	...	70.0	95.0	40.0	23.0	....	30.5	...	..
21	69.0	...	69.5	94.5	39.0	22.5	67.5	29.5	...	62
20	68.5	...	68.5	....	38.0	22.0	....	29.0	...	..
19	68.0	...	68.0	94.0	37.5	21.5	67.0	28.5	...	61
18	67.0	...	67.5	93.5	36.5	....	66.5	27.5	...	..
17	66.5	...	67.0	93.0	35.5	21.0	....	27.0	...	60
16	66.0	...	66.5	....	35.0	20.5	66.0	26.0	...	..
15	65.5	...	65.5	92.5	34.0	20.0	65.5	25.5	...	59
14	65.0	...	65.0	92.0	33.0	....	....	25.0	...	
13	64.5	...	64.5	....	32.0	....	65.0	24.0	...	58
12	64.0	...	64.0	91.5	31.5	....	64.5	23.5	...	..
11	63.5	...	63.5	91.0	30.5	....	....	23.0	...	..
10	63.0	...	62.5	90.5	29.5	....	64.0	22.0	...	57
9	62.0	...	62.0	....	29.0	....	....	21.5	...	..
8	61.5	...	61.5	90.0	28.0	....	63.5	20.5	...	..
7	61.0	...	61.0	89.5	27.0	....	63.0	20.0	...	56
6	60.5	...	60.5	....	26.0	....	....	19.5	...	..
5	60.0	...	60.0	89.0	25.5	....	62.5	18.5	...	55
4	59.5	...	59.0	88.5	24.5	....	62.0	18.0	...	..
3	59.0	...	58.5	88.0	23.5	....	....	17.0	...	..
2	58.0	...	58.0	....	23.0	....	61.5	16.5	...	54
1	57.5	...	57.5	87.5	22.0	....	61.0	16.0	...	..
0	57.0	...	57.0	87.0	21.0	....	....	15.0	...	53

always be added for identification of test conditions.

Perhaps the most difficult field in technical hardness testing, from the standpoint of fundamentals, is that of converting from one scale to another. There the factors of sinking in or piling up, indentation hardening, modulus of elasticity, etc., make it impossible to translate from one arbitrary scale to another. The most that can be done is to calibrate one scale in terms of another for a certain material, such as steel, cold-worked brass, etc. Within the rather restricted limits of such a calibration one scale can be satisfactorily converted into another. That is done for the common tables which have been established, such as Tables II[2] and III[2]. A table made for steel should not, of course, be used for hard carbides, cold-rolled copper, nickel alloys, etc. The error would be greater, if one did so, than might be suspected. Furthermore, an error would go unsuspected since there is nothing in a hardness reading to suggest the presence of error.

Conversion tables dealing with hardness can be only approximate, for it must be understood that a penetration hardness test proceeds until the specimen tested supports the applied load. Yet it is a severely cold-worked metal that actually supports the penetrator, and different metals, different alloys, and different analyses of the same type of alloy have different cold-working properties. Nevertheless, while a conversion table cannot be mathematically exact, it is of considerable value to be able to compare different hardness scales in a general way.

Hardness and Strength

One of the chief values of the indentation hardness is its relationship to the tensile strength of the material. In the ranges where the relationship is reasonably accurate, tensile strengths are given in Tables II and III.

Since fatigue action accounts for a large percentage of service failures it is customary to extend the relationship between values of hardness and tensile strength to include that of fatigue strength. In this respect serious errors will arise unless all factors such as surface condition are taken into account.

The relation between tensile strength and hardness for the usual heat-treated steels is good, and a similar statement can be made as regards the relation between tensile strength and endurance limit. It may therefore be concluded that the relation between indentation hardness and endurance limit also should be good. This, in general, is true but, as recent work has shown, surface conditions may influence considerably the endurance limit of the steel. Such surface conditions cannot be detected by the usual indentation hardness test as used for control purposes. They include stresses induced by drastic quenching, surface decarburization, and peening.

TABLE III

For Hardened Steel and Hard Alloys

Rockwell Hardness Tester				Rockwell Superficial			Diamond Pyramid	Brinell	Tensile Strength
C scale	A scale	D scale	G scale	15-N scale	30-N scale	45-N scale		Standard 3000-kg. Load	Thousand psi.
80	92.0	86.5	....	96.5	92.0	87.0	1865	...	...
79	91.5	85.5	....	....	91.5	86.5	1787	...	...
78	91.0	84.5	....	96.0	91.0	85.5	1710	...	...
77	90.5	84.0	....	....	90.5	84.5	1633	...	...
76	90.0	83.0	....	95.5	90.0	83.5	1556	...	...
75	89.5	82.5	....	....	89.0	82.5	1478	...	...
74	89.0	81.5	....	95.0	88.5	81.5	1400	...	...
73	88.5	81.0	....	....	88.0	80.5	1323	...	...
72	88.0	80.0	....	94.5	87.0	79.5	1245	...	...
71	87.0	79.5	....	....	86.5	78.5	1160	...	...
70	86.5	78.5	....	94.0	86.0	77.5	1076	...	...
69	86.0	78.0	....	93.5	85.0	76.5	1004	...	...
68	85.5	77.0	....	....	84.5	75.5	942	...	...
67	85.0	76.0	....	93.0	83.5	74.5	894	...	...
66	84.5	75.5	....	92.5	83.0	73.0	854	...	...
65	84.0	74.5	....	92.0	82.0	72.0	820	...	...
64	83.5	74.0	....	....	81.0	71.0	789	...	...
63	83.0	73.0	....	91.5	80.0	70.0	763	...	...
62	82.5	72.5	....	91.0	79.0	69.0	739	...	...
61	81.5	71.5	....	90.5	78.5	67.5	716	...	...
60	81.0	71.0	....	90.0	77.5	66.5	695	614	314
59	80.5	70.0	....	89.5	76.5	65.5	675	600	306
58	80.0	69.0	....	....	75.5	64.0	655	587	299
57	79.5	68.5	....	89.0	75.0	63.0	636	573	291
56	79.0	67.5	....	88.5	74.0	62.0	617	560	284
55	78.5	67.0	....	88.0	73.0	61.0	598	547	277
54	78.0	66.0	....	87.5	72.0	59.5	580	534	270
53	77.5	65.5	....	87.0	71.0	58.5	562	522	263
52	77.0	64.5	....	86.5	70.5	57.5	545	509	256
51	76.5	64.0	....	86.0	69.5	56.0	528	496	250
50	76.0	63.0	....	85.5	68.5	55.0	513	484	243
49	75.5	62.0	....	85.0	67.5	54.0	498	472	236
48	74.5	61.5	....	84.5	66.5	52.5	485	460	230
47	74.0	60.5	....	84.0	66.0	51.5	471	448	223
46	73.5	60.0	....	83.5	65.0	50.0	458	437	217
45	73.0	59.0	....	83.0	64.0	49.0	446	426	211
44	72.5	58.5	....	82.5	63.0	48.0	435	415	205
43	72.0	57.5	....	82.0	62.0	46.5	424	404	199
42	71.5	57.0	....	81.5	61.5	45.5	413	393	194
41	71.0	56.0	....	81.0	60.5	44.5	403	382	188
40	70.5	55.5	....	80.5	59.5	43.0	393	372	182
39	70.0	54.5	....	80.0	58.5	42.0	383	362	177
38	69.5	54.0	....	79.5	57.5	41.0	373	352	171
37	69.0	53.0	....	79.0	56.5	39.5	363	342	166
36	68.5	52.5	....	78.5	56.0	38.5	353	332	162
35	68.0	51.5	....	78.0	55.0	37.0	343	322	157
34	67.5	50.5	....	77.0	54.0	36.0	334	313	153
33	67.0	50.0	....	76.5	53.0	35.0	325	305	148
32	66.5	49.0	....	76.0	52.0	33.5	317	297	144
31	66.0	48.5	....	75.5	51.5	32.5	309	290	140
30	65.5	47.5	92.0	75.0	50.5	31.5	301	283	136
29	65.0	47.0	91.0	74.5	49.5	30.0	293	276	132
28	64.5	46.0	90.0	74.0	48.5	29.0	285	270	129
27	64.0	45.5	89.0	73.5	47.5	28.0	278	265	126
26	63.5	44.5	88.0	72.5	47.0	26.5	271	260	123
25	63.0	44.0	87.0	72.0	46.0	25.5	264	255	120
24	62.5	43.0	86.0	71.5	45.0	24.0	257	250	117
23	62.0	42.5	84.5	71.0	44.0	23.0	251	245	115
22	61.5	41.5	83.5	70.5	43.0	22.0	246	240	112
21	61.0	41.0	82.5	70.0	42.5	20.5	241	235	110
20	60.5	40.0	81.0	69.5	41.5	19.5	236	230	108

Note.—General Conversion Values on material harder than about C-70 on the ROCKWELL Hardness Tester will probably be long in dispute because as yet there are few materials hard enough to be brought into that study and because some of those few do not flow nicely under the testing load but have a tendency to crumble nd others do not approach homogeneity.

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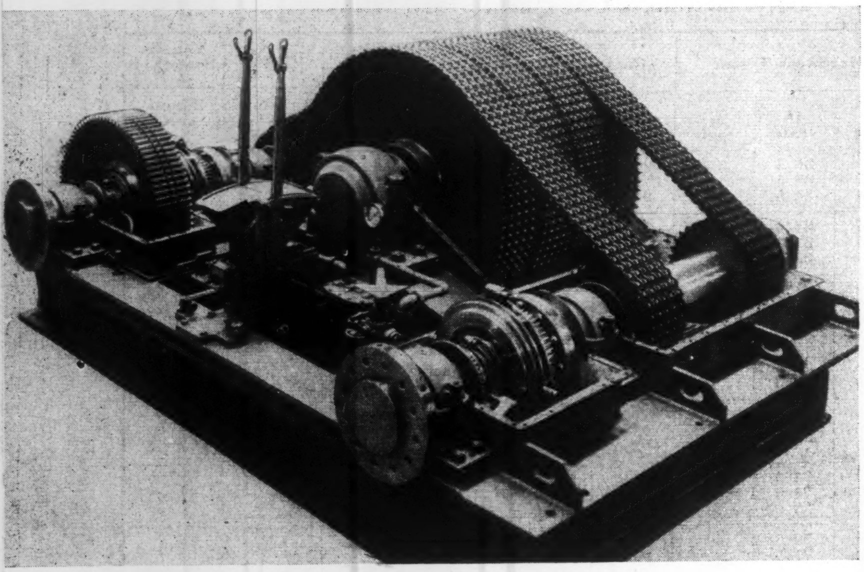
[2] These tables are from a chart issued by the Wilson Mechanical Instrument Co. Inc.

Applications

of Engineering Parts, Materials and Process

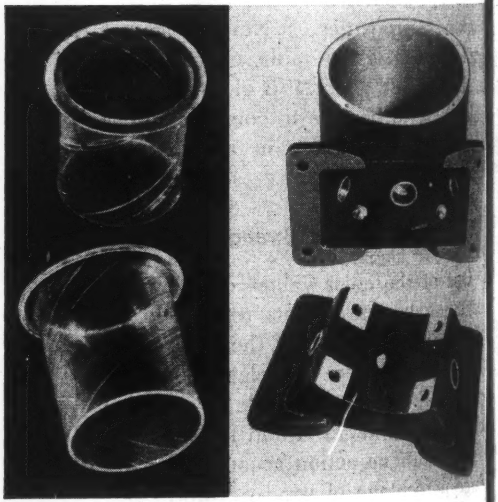


Marine Reduction Gear Uses Chai

PROPELLER drive for the U. S. Navy's 11 foot harbor tugs employs the Morse Cha 3-to-1 speed reduction unit shown at left. Eac of the two flanges at the near ends of the sha is connected to a direct-reversing diesel engi through a hydraulic coupling. The center sha drives the propeller through a coupling on the f side of the large sprocket wheel. Jaw-type clutch enable either engine to be disconnected from th propeller, and permit the rear engine to dri either the propeller or a pair of centrifugal pum for emergency fire service, using as a take-off th sprocket visible on the rear shaft. The four se of chains contain approximately ten thousan individual parts.

Spun Acetate Grommets for Motor Base

ACETATE grommets are used in the motor base shown at right, providing exceptional insulating properties combined with toughness and resistance to oil and moisture. Made by Precision Paper Tube Co., these grommets are supplied spun at one end, inserted in place and subsequently spun over the other end by special tools, utilizing standard drill press equipment. Cooling subsequent to the heating due to the spinning operation shrinks the thermoplastic material so that a tight-fitting grommet results.



Micro Switches Control Transfer Machine

SHOWN at left is one of the built-in controls o a Greenlee automatic transfer machine for production operations on airplane engine cylinde heads. Cover of the housing is removed to sho the rotary limit switch and six Micro switche two of which are employed to control the forwar and reverse strokes of the tapping spindles an the remainder for interlocks and for controllin the automatic cycle.

MACHINE DESIGN'S

Materials Work Sheet

Filing Number 14.01

Inconel

WROUGHT AND CAST

AVAILABLE IN: Cold-drawn, hot-rolled and forged rods and bars; cold-drawn wire; hot-rolled plates; cold-rolled sheets and strips; cold-drawn seamless tubing; welding electrodes; castings

ANALYSES:

	Ni*	Cr	Fe	Mn	Cu	Si	C	S
Wrought	78.5	14	6.5	.25	.2	.25	.08	.015
Cast	77.75	13.5	6	.25	.25	2	.25	.01

*Includes a small amount of cobalt.

PROPERTIES

TENSILE STRENGTH

(psi)

Cold-drawn rod and bar, annealed	80-100,000
as drawn	95-150,000
Hot-rolled rod and bar, annealed	80-100,000
as rolled	85-120,000
Forged rod and bar	85-120,000
Cold-drawn wire, annealed	80-105,000
regular temper	130-175,000
spring temper	165-185,000
Hot-rolled plate, annealed	80-110,000
as rolled	100-140,000
Standard cold-rolled sheet and strip, annealed	80-100,000
Standard cold-rolled hard sheet	125-150,000
Standard cold-rolled full hard strip	145-170,000
Cold-drawn seamless tubing, annealed	80-100,000
as drawn	110-160,000
Castings, as cast	70- 95,000

YIELD STRENGTH

(.2% offset, psi)

Cold-drawn rod and bar, annealed	25- 50,000
as drawn	70-125,000
Hot-rolled rod and bar, annealed	25- 50,000
as rolled	35- 90,000
Forged rod and bar	35- 90,000
Cold-drawn wire, annealed	25- 50,000
regular temper	115-165,000
spring temper	150-175,000
Hot-rolled plate, annealed	30- 60,000
as rolled	45- 95,000
Standard cold-rolled sheet and strip, annealed	30- 45,000
Standard cold-rolled hard sheet	90-125,000
Standard cold-rolled full hard strip	120-160,000
Cold-drawn seamless tubing, annealed	30- 50,000
as drawn	65-140,000
Castings, as cast	30- 45,000

BRINELL HARDNESS

(3000 *kg*)

Cold-drawn rod and bar, annealed	120-170
as drawn	180-290
Hot-rolled rod and bar, annealed	120-170
as rolled	140-210
Forged rod and bar	140-210
Castings, as cast	160-190

MACHINE DESIGN is pleased to acknowledge the collaboration of The International Nickel Company Inc. in this presentation.

ELONGATION IN 2 INCHES

(per cent)

Cold-drawn rod and bar, annealed	50-35
as drawn	30-15
Hot-rolled rod and bar, annealed	50-35
as rolled	45-30
Forged rod and bar	45-20
Cold-drawn wire, annealed	50-25
regular temper	12- 3
spring temper	10- 2
Hot-rolled plate, annealed	50-35
as rolled	40-20
Standard cold-rolled sheet and strip, annealed	50-35
Standard cold-rolled hard sheet	15- 2
Standard cold-rolled full hard strip	10- 2
Cold-drawn seamless tubing, annealed	50-35
as drawn	20- 2
Castings, as cast	30-10

REDUCTION OF AREA

(per cent)

Cold-drawn rod and bar, annealed	70-60
as drawn	60-40
Hot-rolled rod and bar, annealed	70-60
as rolled	65-50
Forged rod and bar	65-50

IZOD IMPACT

(ft-lbs)

Cold-drawn rod and bar, annealed	120 plus
as drawn	100-70
Hot-rolled rod and bar, annealed	120 plus
as rolled	120-100
Forged rod and bar	120-100
Castings, as cast	85-70

CREEP STRENGTH OF HOT-ROLLED RODS

(psi)

Temperature (deg F)	Stress to Produce .1% Elongation in 10,000 hours	Stress to Produce 1% Elongation in 10,000 hours
800	48,000	.....
900[1]	28,000	39,000
1000	14,000	22,000
1100	6,000	11,000

---

[1] Below 900 F the creep stress exceeds the yield strength, .2 per cent offset, as determined by the short-time tensile test.

Materials Work Sheet

ELEVATED-TEMPERATURE PROPERTIES OF HOT-ROLLED RODS

(short-time tests)

Temperature (deg F)	Tensile Strength (psi)	Yield Strength (.2% offset, psi)	Elongation in 2 inches (per cent)
70	81,000	36,000	49.5
200	81,000	32,000	48.5
400	78,000	28,000	47.5
600	79,000	27,000	51
800	83,000	28,000	50
1000	79,000	22,000	21
1200	71,000	22,000	5.5
1400	47,000	19,000	12
1600	23,000	.....	32
1800	15,000	.....	51
2000	11,000	.....	66.5

LOW-TEMPERATURE PROPERTIES

Temperature (deg F)	Yield Strength .2% offset (psi)	Tensile Strength (psi)	Elongation in 2 inches (per cent)	Reduction of Area (per cent)	Hardness (Rockwell)
ANNEALED					
Room	36,800	93,800	37.3	64.1	82B
-110	42,400	106,450	39.8	64	87B
Room[1]	36,200	93,000	36.5	64.4	82B
COLD-DRAWN[2]					
Room	147,700	152,100	7	49.3	31C
-110	154,900	163,900	9.8	51.2	36C
Room[1]	147,400	151,900	7.3	49.3	32C

---

[1] Cooled to and held at -110 F. for several hours prior to testing at room temperature.

[2] 50 per cent reduction in cross-sectional area by cold drawing

PHYSICAL CONSTANTS

Specific Gravity	
wrought	8.51
cast	8.3
Weight (lb per cu in.)	
wrought	.307
cast	.3
Melting Range (deg F)	
wrought	2540-2600
cast	2500-2550
Specific Heat (Btu/lb/deg F) 32-212 F	
wrought and cast	.11
Coef. of Thermal Expansion (in./in./deg F) 32-212 F	
wrought	.0000064
Thermal Conductivity (Btu/sq ft/hr/deg F/in.) 32-212F	
wrought	104
Modulus of Elasticity in Tension	
wrought and cast	31,000,000
Modulus of Elasticity in Torsion	
wrought and cast	11,000,000
Poisson's Ratio	
wrought	.29

CHARACTERISTICS

Containing approximately 80 per cent of nickel and 14 per cent of chromium, this nickel-chromium-iron alloy has high strength and is nonmagnetic down to −40F. Developed primarily for freedom from tarnishing and other corrosion effects in the food industries, it is resistant to many other types of corrosion as well. Offering freedom from sca and intercrystalline attack, it sees wide usage in elevat temperature applications. Inconel castings possess about same corrosion resistance as wrought Inconel and are u under severe corrosive conditions where neither nickel Monel is satisfactory.

APPLICATIONS

Being able to withstand repeated heating and cooling a temperature range from 0 to 1600 degrees Fahr., it is outstanding alloy for airplane-engine exhaust manifolds. stiffness and high strength make it particularly suitable a for springs that operate at high temperatures. Because its resistance to oxidation and its strength at high temper tures it is used in various heat treating applications such annealing baskets, nitriding hoods, carburizing boxes, e Also used extensively in the food and chemical industri where it serves ideally for heaters, stills, condensers, tank piping, valves, etc. In the photographic equipment field is used for pumps, piping, reels, shafts, trays, etc.

FABRICATION

MACHINABILITY:

Cold-drawn, annealed rods offer best machinability. Tub to be subjected to simple machine work, such as threadin should be specified as "low-temperature normalized". If th tubes must be machined to close tolerances in straightnes and ovality they should be specified as "high-temperatu normalized". This is because "as-drawn" material has hig skin stresses which, when relieved during machining, ma cause warpage and distortion. Stress-equalized tubing has slight oxide tarnish. High-speed tools, carefully heat treate and with sharp cutting edges are used. High cutting speed and feeds are avoided and the work is flooded with a sul phur-base cutting oil which must be removed completely be fore the machined part is exposed to elevated temperatures as in welding. Where the machined part is to be used unde corrosive conditions, a good smooth finish should be specified because rough, torn surfaces often provide focal points fo acceleration of corrosion. When specifying hot-rolled rounds squares and hexagons for machining, allowance should be made in over-all size to insure that the finished size will have properly cleaned surfaces. Recommended allowances are here listed.

Allowances for Finish Machining of Hot-rolled Products

Size (inches)	Allowance for Rounds	Allowances for Flat Squares & Hexagons
Up to ⅞ incl.	⅛-in. on diam	⅛-in. on each side
1 to 1⅞ incl.	⅛-in. on diam	$\frac{3}{16}$-in. on each side
2 to 2⅞ incl.	$\frac{3}{16}$-in. on diam	$\frac{3}{16}$-in. on each side
3 to 4½ incl.	¼-in. on diam	$\frac{3}{16}$-in. on each side

DRILLING:

Best results are obtained with heavy-duty, super high-speed steel (18-4-1 + cobalt) twist drills having polished flutes and point angle of 135 degrees. For drills 1/16 to 3/16-inch diameter, cutting speed of 40 feet per minute is recommended. For drills ¼ to ¾-inch diameter, cutting speed of 45 feet per minute is recommended and for drills 13/16 to 3 inches diameter, suitable cutting speed is 30 feet per minute. These cutting speeds are roughly 20 per cent lower than those recommended for drilling Monel and nickel; roughly 33 per cent higher than those recommended for drilling unhardened "K"

Monel and "Z" nickel. As is the case when drilling other high-nickel alloys, drills are kept feeding into the work, for if they are permitted to dwell without cutting they polish and harden the metal at the base of the hole, making it difficult to resume cutting as well as dulling the drill. Work is flooded with cutting oil during drilling.

REAMING:

The drilled hole preceding reaming should be specified to a diameter which leaves sufficient material to permit the reamer to "bite". If insufficient material is left, the reamer will not cut but will squeeze into the hole and burnish and harden the inside diameter to an extent that may result not only in an undersize hole but in a dull reamer as well. Spiral-fluted, high-speed steel reamers with narrow lands and well-polished flutes are used generally and are kept sharp at all times. To obviate the possibility of digging and chattering, ample lubrication with a sulphur-base cutting oil is employed on all reaming operations. Recommended amounts of material to be removed by reaming in various size holes are listed below:

Amount of Material to be Removed by Reaming

Hole Diam (inches)	Material to be removed
⅛ to ¼	.005-in. on diam
¼ to ½	.008 to .012-in. on diam
½ to 1	.015-in. on diam
1 to 2	.031-in. on diam

TAPPING:

Because this is a tough alloy it requires a slightly larger tap drill for a given thread than is customarily considered standard. A tap-drill size which will result in 75% depth of thread is recommended. Such threads are but slightly if at all weaker than full-depth threads and since Inconel is highly ductile, it will flow into the roots of the tap thread, producing what for all practical purposes is a full-depth thread. A generous amount of cutting oil always is used in tapping operations because without lubrication this alloy has a tendency to gall on the tap. National standard, four-fluted, high-speed steel plug taps, with ground threads and 7-degree spiral flutes, and four-fluted, spiral-pointed plug taps are recommended for machine tapping. Inconel can be tapped at approximately 10 to 15 feet per minute.

PERFORATING:

The minimum hole diameter that can be punched in this material on an economical production basis must be larger than the thickness of the sheet up to thicknesses of approximately 5/32-inch. For heavier plate, the minimum diameter of the hole may be equal to the thickness of the sheet. Recommended minimum hole diameters for various sheet thicknesses are listed below and apply to soft and quarter-hard tempers:

Minimum Punched Hole Diameters

Sheet Thickness (inches)	Min. Hole Diam (inches)
.018 to .034 incl.	Sheet thickness x 1.5
.037 to .070 incl.	Sheet thickness x 1.3
.078 to .140 incl.	Sheet thickness x 1.2
5/32-inch and heavier	Sheet thickness x 1

The hole diameters listed above are only general recommendations. In particularly favorable setups it is possible to punch holes smaller than the sizes listed. Die and punch clearances for light-gage sheets are the same as for neat steel punching. For ¼-inch and heavier plate, less clearance than for steel often is used to produce clean holes, free from burrs. A heavy, sulphur-base oil is used as a lubricant in punching and is removed thoroughly before the punched sheet is annealed or heated for any other purpose.

COLD WORKING:

Amount of cold working, regardless of type, has a critical influence on the ductility of this alloy. Too little cold working can be harmful as too much. For example, if only about 10 per cent thickness reduction is effected in a cold-working operation, the full ductility of the metal cannot be restored by annealing even though the hardness is reduced to the level of soft material. On the other hand, internal fractures, which cannot be eliminated by annealing, may result if the material is cold worked excessively. Inconel should be cold worked not less than 20 per cent and not more than 50 per cent reduction of thickness between anneals when deep drawing or spinning.

DEEP DRAWING:

Inconel has good ductility and can be deep drawn to any shape that can be produced from steel of deep-drawing quality. Generally the same dies used for drawing steel or brass can be used without alteration although in some cases where severe draws of extreme accuracy are demanded, modifications in die materials, die construction, lubrication and annealing will be required. Cold-rolled sheets and strips in soft temper and with fine to medium grain are most suitable for deep drawing. Die radii over which the metal is drawn should be as large as possible without causing wrinkling. Usually, drawring and punch-nose radii for light-gage cylindrical shells are from 5 to 12 times the stock thickness. Corner-edge radius for a rectangular shell should range from 4 to 10 times the stock thickness.

SPINNING:

Inconel requires more power in spinning than do softer metals such as copper, brass and aluminum. Also, since it work-hardens more rapidly, it requires more frequent annealing than the copper-base alloys and aluminum. In general, roller type tools are preferred because they create less friction than do the solid-nose types. Inconel is spun at speeds from one-half to three-quarters of those used for the softer metals and a heavy-bodied lubricant is employed. Yellow laundry soap also is used frequently, as are beeswax and tallow or a mixture of the two. Lubricants containing sulphur or lead should not be used if the spun parts are to be annealed, because of the embrittlement caused by these two elements.

WELDING:

Prior to welding, surfaces are cleaned thoroughly and the thin darkly colored oxide film is removed in the immediate vicinity of the areas to be welded. Electric-arc, oxyacetylene and resistance welding are the types most predominantly employed on Inconel. The oxyhydrogen flame is not practicable because of its low temperature. Hammer welding is not possible because fusion does not occur unless the metal

Materials Work Sheet

is melted. After welding, no thermal or chemical (passivation) treatments are necessary or recommended to retain or restore corrosion resistance. Since the coefficient of expansion is practically the same as for steel, warping and buckling resulting from a welding operation is essentially the same as for a similar construction of steel. Electric welding, if applicable, will produce less buckling than gas welding. Inconel can be joined to plain carbon steel by metal arc or oxyacetylene welding, silver brazing or soft soldering. When joining with 18-8 stainless steel, Monel or nickel, either metal-arc or oxyacetylene welding is recommended.

SILVER BRAZING AND SOFT SOLDERING:

Strength and corrosion resistance of properly designed and executed silver-brazed joints are greater than those of soft-soldered joints. Soft solder is inherently weak and dependence for strength must usually be placed on riveted, lock-seamed or spot-welded joints, with a soft solder acting only as a sealing medium. Strength of a properly made silver-brazed joint should be approximately 50,000 pounds per square inch in tension and 30,000 pounds per square inch in shear at room temperature. These values can be used in design calculations with a factor of safety of five. Maximum temperature at which silver-brazed joints may be expected to carry an appreciable load is 600 degrees Fahr. and at that temperature their tensile strength is about 50 per cent of its value at room temperature.

CORROSION RESISTANCE

Inconel remains bright for many years in indoor atmospheres and in clean country air. It is not subject to "fogging" in damp, sulphurous atmospheres. It offers practically complete resistance to corrosion in distilled and fresh waters as well as in corrosive natural waters. In rapidly flowing sea water its resistance is moderate and in quiet or stagnant sea water pitting may occur, especially where barnacles attach themselves to the metal surface. Inconel is unaffected by the majority of neutral and alkaline salt solutions and has good resistance to solutions of most oxidizing acid salts, including chromates, dichromates, permanganates, nitrates and copper sulphate. It is not resistant, however, to solutions containing appreciable amounts of highly corrosive ferric, cupric and mercuric chlorides. Resistance to corrosion by sulphuric and hydrochloric acids is fair.

GALVANIC CORROSION

In neutral salt solutions and waters, Inconel, Monel, nickel, copper and high-copper alloys ordinarily may be coupled without seriously accelerated attack. In sea water it is wise to avoid couples of yellow brass with Inconel where the exposed area of Inconel is considerably greater than that of the brass. With approximately equal areas, or where the area of the Inconel is smaller than the brass, such couples are considered safe.

ANNEALING

Through proper combinations of cold working and annealing, fairly wide ranges of strength and hardness are obtainable. Inconel is not an age-hardening alloy and cold working is the only available means by which it can be hardened. Internal stresses caused by cold working are relieved most completely by heating for ½ to 1 hour at 1200 degrees Fahr. At this temperature only slight softening occurs. Softening by annealing begins at about 1600 degrees Fahr. and is reasonably complete in 10 to 15 minutes heating at 1800 degrees Fahr. Grain growth may be excessive above 1800 degrees although heating at 1900 degrees Fahr. for only approximately five minutes will effect softening without undue grain growth. Rate of cooling has no effect on softening. Welded joints of Inconel do not require annealing or other heat treatment to insure best corrosion resistance.

DATA ON STOCK FORMS

Plain Finished
Standard Cold-Rolled Sheet

THICKNESS TOLERANCES*

Thickness (inches)	Tolerance (inches) Plus	Minus
.018 to .034	.002	.002
Over .034 to .062	.003	.003
Over .062 to .125	.004	.004
Over .125 to .187	.005	.005
Over .187 to .218	.006	.006
Over .218 to .234	.007	.007
Over .234 to .250	.008	.008

*Apply to sheets not over 50 inches wide by not over 120 inches long.

Hot-Rolled Rods and Flats

TOLERANCES

ROUNDS

Diameter (inches)	Tolerance (inches) Plus	Minus
Up to 1 inch	.016	.016
Over 1 to 2	.031	.016
Over 2 to 4	.047	.031
Over 4	.125	.063

FLATS

Thickness	Width	Thickness Plus	Thickness Minus	Width Plus	Width Minus
⅛ to 1	½ to 1	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{1}{64}$
⅛ to 1	Over 1 to 2	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{64}$
⅛ to 1	Over 2 to 4	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{3}{64}$	$\frac{1}{32}$
⅛ to 1	Over 4 to 10	$\frac{1}{64}$	$\frac{1}{64}$	⅛	$\frac{1}{16}$
Over 1 to 2	Over 1 to 2	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{64}$
Over 1 to 2	Over 2 to 4	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{3}{64}$	$\frac{1}{32}$
Over 1 to 2	Over 4 to 8	$\frac{1}{32}$	$\frac{1}{64}$	⅛	$\frac{1}{16}$

HEXAGONS AND SQUARES

Across Flats	Plus	Minus
Up to $1\frac{3}{16}$	.016	.016
Over $1\frac{3}{16}$	.031	.031

MATERIAL DESIGNATIONS

ASTM	AMS	Army-Navy	Navy
HOT ROLLED RODS B166-41T	5665	AN-QQ-N-268-1[1]	47N1a[1]
COLD DRAWN RODS B166-41T	5665	AN-QQ-N-268-1[1]	47N1a[1]
FORGINGS B166-41T	5665	AN-QQ-N-268-1[1]	47N1a[1]
COLD ROLLED SHEET B168-41T	5540A	AN-QQ-N-271a-2[2]	47N1a[2]
COLD ROLLED STRIP B168-41T	5540A	AN-QQ-N-271a-2[2]	47N1a[2]
HOT ROLLED PLATE B168-41T	....	....	......
SEAMLESS TUBING B167-41T	5580A	AN-WW-T-831-1[3]	49T13[3]
WELDED TUBING	....	AN-WW-T-833[4]	49T14[4]
COLD DRAWN WIRE	....	AN-N-4[5]	47N1a[5]
CONDENSER TUBES B163-41T	....	....	......
CASTINGS No government or ASTM specifications.			

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[1] For aeronautical use AN-QQ-N-268-1 supersedes Army Spec. 57-174A and Navy Spec. 47N1a.

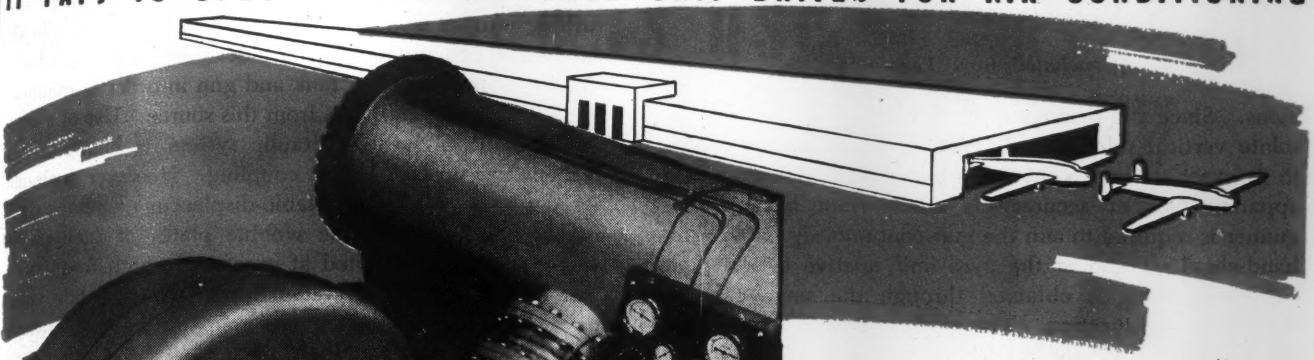
[2] For aeronautical use AN-QQ-N-271a-2 supersedes 57-174A and 47N1a.

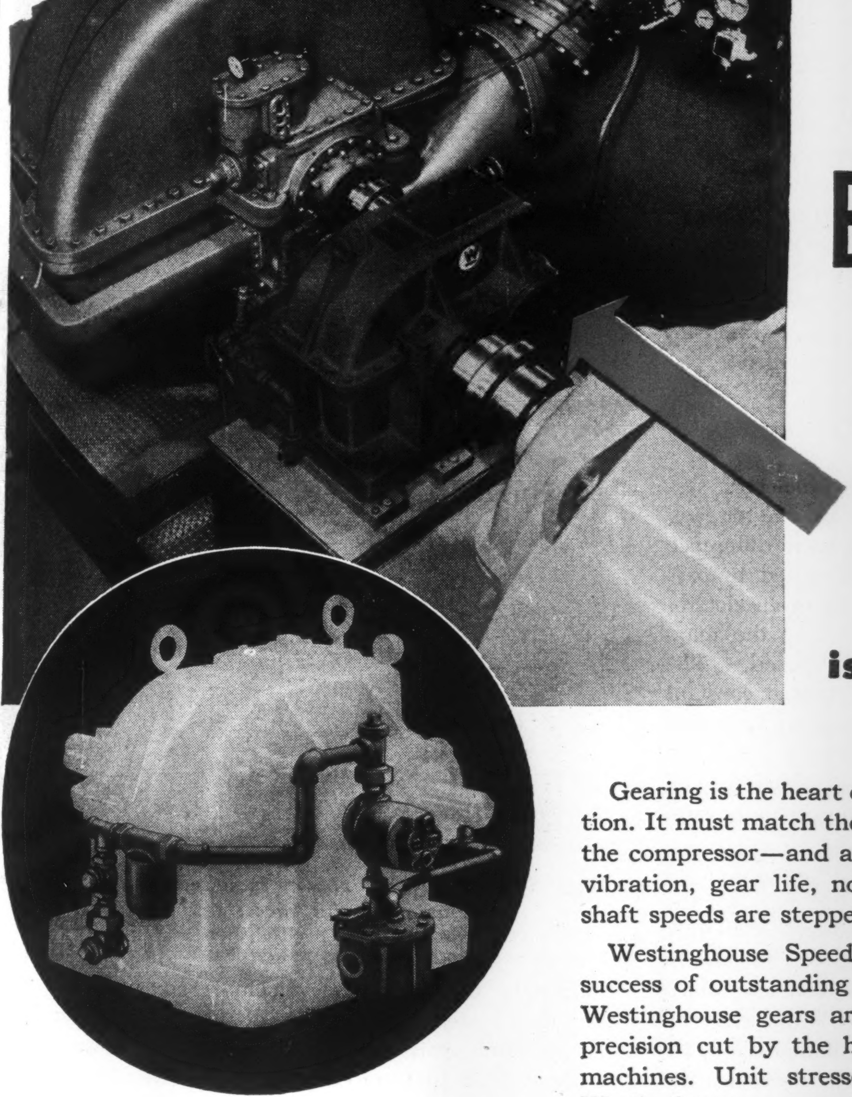
[3] For aeronautical use AN-WW-T-831-1 supersedes 57-174A and 49T13.

[4] For aeronautical use AN-WW-T-833 supersedes 57-174A and 49T14.

[5] For aeronautical use AN-N-4 supersedes 57-174A, 46R6, 47N1a and W-41.

IT PAYS TO SPECIFY WESTINGHOUSE UNIT DRIVES FOR AIR CONDITIONING





MORE EFFICIENT

air conditioning

. . . because

GEARING

is matched to the job!

EXTERNAL FORCED-FEED LUBRICATION

Entire system is external, permitting easy maintenance. The oil is continuously strained and cooled. The oil pump is always primed, ready for instant duty. These are additional quality features of Westinghouse air conditioning gear units.

Gearing is the heart of a successful air conditioning installation. It must match the characteristics both of the motor and the compressor—and at the same time solve the problems of vibration, gear life, noise and lubrication that occur when shaft speeds are stepped up to 6000 rpm and more.

Westinghouse Speed Increasers help to account for the success of outstanding air conditioning installations because Westinghouse gears are designed to fit the job. Teeth are precision cut by the hobbing process on specially designed machines. Unit stresses are low. Skilled workmen make Westinghouse gears practically wearproof, insuring long life, quiet operation.

Westinghouse Speed Increasers are one of the reasons it pays to specify complete Westinghouse Unit Drives for air conditioning installations. Investigate—write for Bulletin 3044. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

J-07198A

Westinghouse **GEARED DRIVES**

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Gun Stabilizer

(*Concluded from Page* 92)

nions. Since the monogyro control does not have an absolute vertical reference, the gun may not always return to its exact starting point when disturbed. However, this apparent lack of accuracy is unimportant because the gunner is required to aim the gun continuously anyway by handwheel rotation of the gyro unit relative to the gun.

Power aiming is obtained through the same controls that cause stabilization. The gyro unit is so attached to the gun that it may be rotated by means of a handwheel, flexible shaft, and worm gear, *Fig.* 2. The rate of turning the handwheel affects the gyro member in the same manner as angular velocity of the gun; the gunner aims the gun by precessing the gyro in accordance with his rate of turning, and the stabilizer tends to maintain the aim.

Power in the form of a servo-mechanism is used for stabilizing the tank gun rather than a gyroscope large enough to resist the disturbing torques directly. Because the required accelerations are excessive, an electric motor is impractical; high angular accelerations could be obtained with an electric motor drive, but the unit would be too large for the limited space available in the turret.

Controlling Oil Flow to Servo Cylinder

The servo mechanism is a composite hydroelectric system having two constant-displacement pumps, one for each end of the hydraulic cylinder, *Fig.* 3. Pressure difference for the pumps is controlled by a pair of seated by-pass valves regulated by the teeter bar armature of an electromagnetic unit, the entire assembly, including the magnetic valve-control device, being oil-immersed. The double pump utilizes three spur gears running at constant speed and the discharge from each pump normally passes through one of the seated valves. If, however, a valve is partially closed by a differential pull of the magnet coil the pressure increases, forcing oil into the cylinder supplied by that pump.

Summarizing, the complete sequence of operation of the stabilizer is as follows: Referring to *Fig.* 3, when the tank pitches or vibrates, (1) the gyro control is slightly displaced from its former vertical position, (2) the resulting precession of the gyro makes electrical contacts, shorting resistances through the silverstat, (3) the changed current alters the two electro-magnets regulating the teeter valves, (4) the operation of the oil valves decreases the pressure on one side of the hydraulic piston and increases the pressure on the other side, (5) the piston is forced toward the low-pressure side, and (6) the movement of the gun is controlled accordingly since the piston is fixed to the gun.

Recoil of the gun barrel after firing results in large gravity unbalances. To prevent the violent disturbances which this would cause, an auxiliary control is provided: A switch closes when the gun recoils, furnishing current to an auxiliary magnet coil of the valve in a manner to supply supporting pressure for breech heaviness during recoil. The recoil adjustment need not be precise because the gyro control through its silverstat regulation of the other magnet coils compensates for any remaining differences.

The system develops torques equal to the combined disturbing torques from all coupling members. The cylinder, valves and connecting pipes are designed to give relatively small coupling between tank and gun in order to minimize the additional disturbance from this source. Use of a high-pressure low-delivery hydraulic system is highly advantageous in securing the low coupling. However, hydraulic servo-motors involving variable-displacement pumps could not be used because the wobble plates of such pumps would have to be shifted at excessively high frequencies. Nor could a hydraulic system using two-way slide valves be used because of the complications presented by friction and the large movements.

The present mono-gyro control was developed from the original type of stabilizer which utilized two gyros, an upper and a lower one. The upper gyro in that case provided an absolute vertical reference. It was discovered, however, that satisfactory stabilization could be obtained by using only the velocity-responsive gyro. With the dual system, the response of the upper gyro to lateral accelerations was so pronounced that firing was accurate only at fairly uniform tank velocities. Aside from the advantage of simplicity in omitting one of the two gyros, the response of the mono-control system to lateral accelerations was greatly reduced.

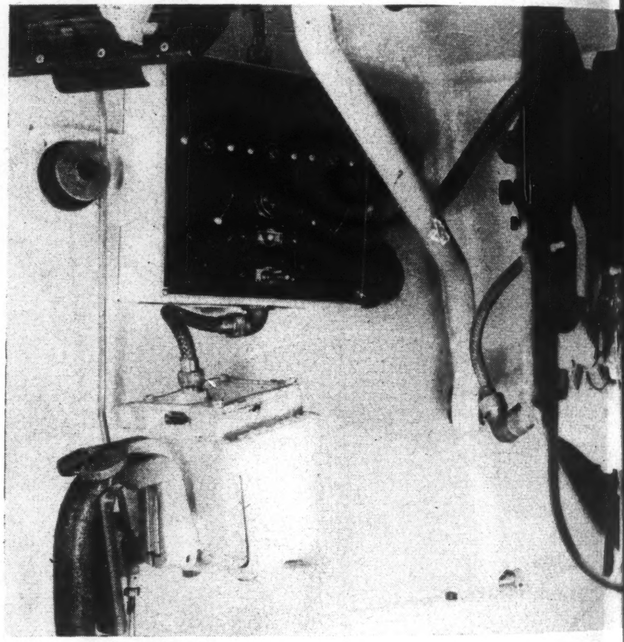
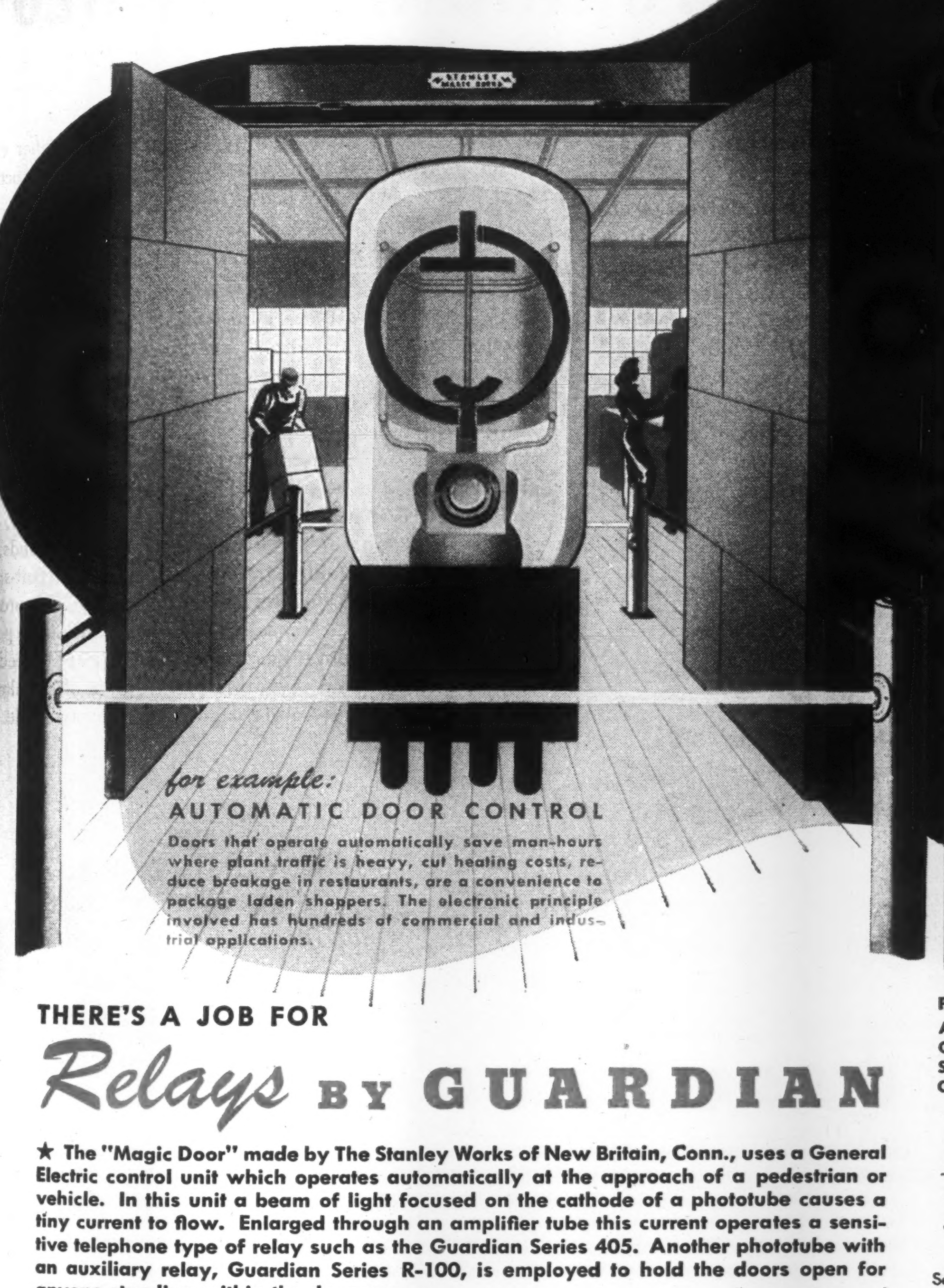


Fig. 5—Control box, shown mounted in tank, contains adjustments for recoil and stiffness

Before the development of the tank-gun stabilizer, gyros of the velocity type were in use for certain regulatory devices involving gyroscopic anti-hunting elements. The principles involved in the stabilization of the tank gun as well as in the anti-hunting devices are essentially the same. In general terms, the result is the stabilization of a component mass with respect to space when mounted on the principal, moving mass. This is a fundamental problem in many industries and this basic gyro stabilizing system, or modified forms, will find peacetime applications.

wherever a tube is used . . .



for example:
AUTOMATIC DOOR CONTROL

Doors that operate automatically save man-hours where plant traffic is heavy, cut heating costs, reduce breakage in restaurants, are a convenience to package laden shoppers. The electronic principle involved has hundreds of commercial and industrial applications.

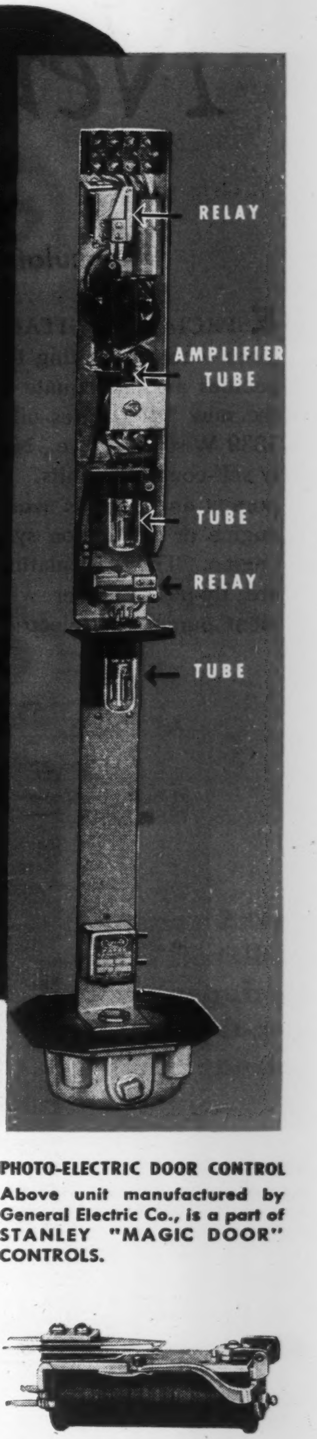


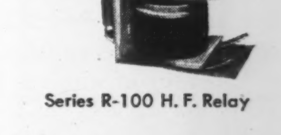
PHOTO-ELECTRIC DOOR CONTROL
Above unit manufactured by General Electric Co., is a part of STANLEY "MAGIC DOOR" CONTROLS.

THERE'S A JOB FOR
Relays BY GUARDIAN

★ The "Magic Door" made by The Stanley Works of New Britain, Conn., uses a General Electric control unit which operates automatically at the approach of a pedestrian or vehicle. In this unit a beam of light focused on the cathode of a phototube causes a tiny current to flow. Enlarged through an amplifier tube this current operates a sensitive telephone type of relay such as the Guardian Series 405. Another phototube with an auxiliary relay, Guardian Series R-100, is employed to hold the doors open for anyone standing within the doorway.

The telephone type of relay is extremely sensitive and able to operate on the small current supplied through the electronic circuit. The auxiliary relay, Series R-100, is required to handle a greater current. It is a small, efficient relay having a contact capacity up to 1 KW at frequencies up to and including 28 megacycles. Contact combinations range up to double pole, double throw. Standard coils operate on 110 volts, 60 cycles, and draw approximately 7 V. A. Coils for other voltages are available. For further information write for Bulletin R-6.

Consult Guardian whenever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.



Series 405 Telephone Type Relay

Series R-100 H. F. Relay

GUARDIAN ELECTRIC

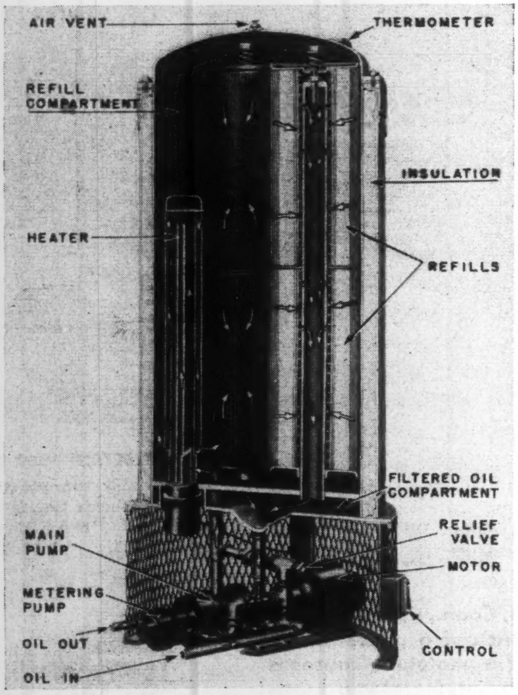
1601-L W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

New PARTS AND MATERIALS

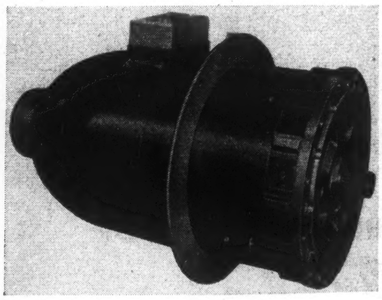
Recirculating Oil Clarifiers

ESPECIALLY SUITABLE for lubrication systems of engines where operating temperatures are low or pump capacities are inadequate for maximum filtration efficiency, the new DRU series oil clarifiers of Briggs Clarifier Co., 1339 Wisconsin Ave., N.W., Washington 7, are completely self-contained units. They contain electrically operated pumps and heaters which operate independently of the engine or lubrication system, and can be adapted to any engine. The recirculating clarifier is composed of a standard by-pass clarifier with dual rotary, positive-displacement pumps and electric heater installed in the base beneath the unit. Recirculation of oil is independent of oil entering and leaving the clarifier, and is accomplished with dual pumps. One pump meters outgoing oil and the other recirculates the oil through the refills. By selecting the proper size recirculating pump for the number of refills, an accurate flow is maintained. Correct temperature of the oil is accomplished by a bayonet type heater, the watt density of which is not sufficient to scorch the oil on the heater surface. As a further protection, the element is installed so that a high velocity of oil is maintained around it, assuring uniform heat dissipation throughout the clarifier. The heater and the motor are interconnected on one electric circuit protected by an overload cutout. If the pump stops operating, the heater is cut off. Heat loss is reduced to a minimum by insulation. Clarifier case, pump and heater housing are all-steel welded construction.



AC Power Supply Systems

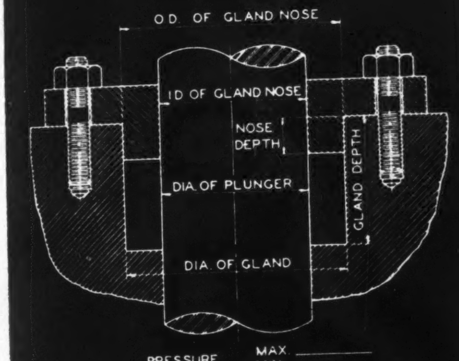
CONSISTING OF variable-frequency alternators, carbon-pile voltage regulators and compounding units, the new alternating-current power supply systems announced by the Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J., are designed to provide a source of either constant or variable frequency for alternating-current power or for rectified direct-current power. The systems are available in two models, rated at 25 kva, 18.75 kw, and 66.6 kva, 50 kw. They weigh 49 and 129 pounds, respectively. By installing the alternators on constant-speed drives, driven by the aircraft main engines, a source of constant frequency is available. Rectified alternating power can be obtained from either constant or variable-speed operation over the rated operating speed range of the alternators. Increased direct-current power is thus available. The alternators incorporate an integral exciter, and brushes are designed for service at high altitude. A floating-type flexible torque drive shaft compensates for any slight misalignment. Sealed, prelubricated bearings provide lubrication under continuous operating conditions. An integral fan plus a tubular armature shaft maintain minimum operating temperatures. The 25 kva alternator delivers a rated output between 7200-8800 revolutions per minute, while the 66.6 kva alternator operates between 5400-6600 revolutions per minute.



Split-Contact Switches Offered

TO SIMPLIFY COMPLEX electric circuits, Micro Switch Div., Freeport, Ill., has introduced a new line of split-contact micro switches. With this double-throw, split-contact control it is possible to switch operation from a direct-current to an alternating-current control. Two sets of con-

WHEN SEEKING PACKING AID PLEASE SUPPLY FULL DATA



PRESSURE MAX ______ MIN ______

TEMPERATURE MAX ______ MIN ______

MEDIUM ______

MOVEMENT ☐ ROTARY ☐ RECIPROCATING

SPEED ______ PER MINUTE

Full-size sheets of this sketch will be sent on request.

•

There is no such thing as a stock item, or a standard size packing. They are tailor-made to your needs.

That is why complete data should be furnished when requesting advice or prices. If we have the information listed above, we can then design a packing installation for you which will hold the seal better and longer than even you had originally estimated.

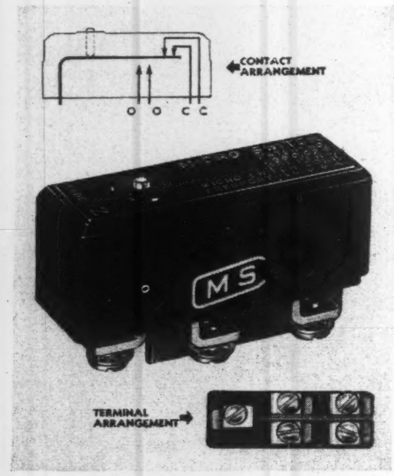
All VIM Leather Packings are made to order...

Forty years of packing experience have taught us that scarcely any two installations are exactly alike in their requirements. That is why there's no "take-it-or-leave-it" in our answers to your requests for application data.

VIM Leather Packings, supplied in "V," "U," Cup or Flange form, are *engineered* to the job. A huge stock of moulds has been built up over the years, so it is very possible that despite the many variables, we can serve you immediately.

To get the whole story of this service and packing design data which will help you, write for a copy of "Houghton's Handbook on Hydraulic & Pneumatic Leather Packings"—free to engineers. E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Phila. 33, Pa.

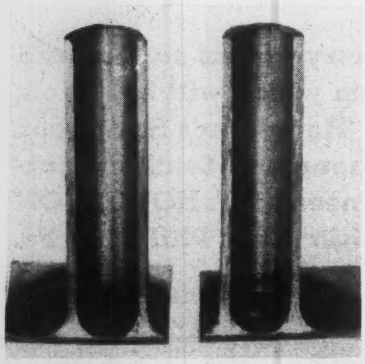
HOUGHTON'S *Engineered* **VIM** *Leather Packings* tacts are mechanically interlinked but electrically isolated, and the transfer action is a matter of a few milliseconds. Also possible with this switch is the control of four isolated circuits by pairs, eliminating the use of relays and other isolating means from the circuit. This saves weight and bulk and gives more accurate and speedy response. The switches have two contacts on both the normally open and normally closed sides. Outside dimensions are the same as the basic single-pole micro switch.



Plastic Insulation Tape

FOR WIDELY divergent applications, a new plastic tape known as "Fibron" has been announced by Irvington Varnish & Insulator Co., Irvington 11, N. J. It is used for insulating wires, cables and electrical equipment; for splicing cables; and for protecting wiring, piping and equipment exposed to caustic or corrosive fumes, oil, grease, acids, alkalis or moisture. Produced from Vinylite resin, the tape is flexible and elastic, heat-sealing, flame-resistant, and high in dielectric and mechanical strength.

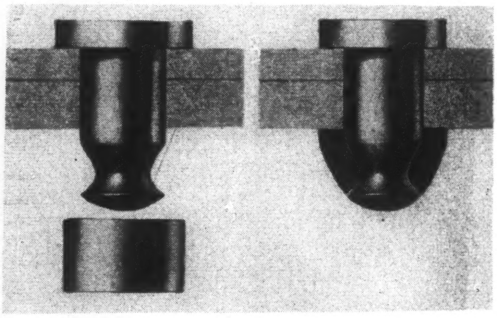
Free-Flowing Solder for Aluminum



WITH THE NEW free-flowing solder, EutecRod 199, announced by Eutectic Welding Alloys Co., 40 Worth street, New York 13, sheet aluminum can be lock-seamed or lapped and spot-welded or riveted, and the joint sealed. The new rod supplants the alloy previously known as No. 19B, and is used with Autochemic Eutector Flux 199 which will flow readily on aluminum. In long laps the rod will make joints of moderate strength, but it should be used generally as a seal. It will work on cast aluminum as well as on wrought aluminum, and on steel, copper and nickel alloys, and is suitable for applications where the completed joint will not be heated over the boiling point of water under working conditions. Its "low temperature" of application, 400 degrees Fahr., makes possible the joining of thin sheet metal without danger of distortion. The rod is available in ⅛-inch size in standard packages of 200, 100, 50 and 25 pounds.

Fastener Has High Shear Strength

DESIGNED TO save assembly time, materials, and to cut down weight, the new "Hi-Shear" rivets developed by Pheoll Mfg. Co., 5700 West Roosevelt road, Chicago 50, consist of two parts; the pin and the collar. The rivet pin is alloy steel, heat treated to a minimum tensile strength of 125,000 pounds per square inch, and cadmium-plated. Inasmuch as this hard material cannot be squeezed or hammered down to form a head, a malleable collar is provided, made of A17ST aluminum alloy, anodized. The rivet pins are the same as comparable sizes of AN hexagon-head aircraft bolts in regard to material, heat treatment, finish and body diameter. The shear strength too is the same as that of the corresponding size standard aircraft bolt. Although the rivets are installed with riveting equipment, they are essentially threadless bolts. By means of a conical bore in the end, the one-piece rivet set swages the collar into the grooved pin end. The set is placed over the collar and as pressure is applied the soft collar is forced into the groove. The ring of waste material, pinched off when the collar is formed, is expelled through the waste port in the rivet set.



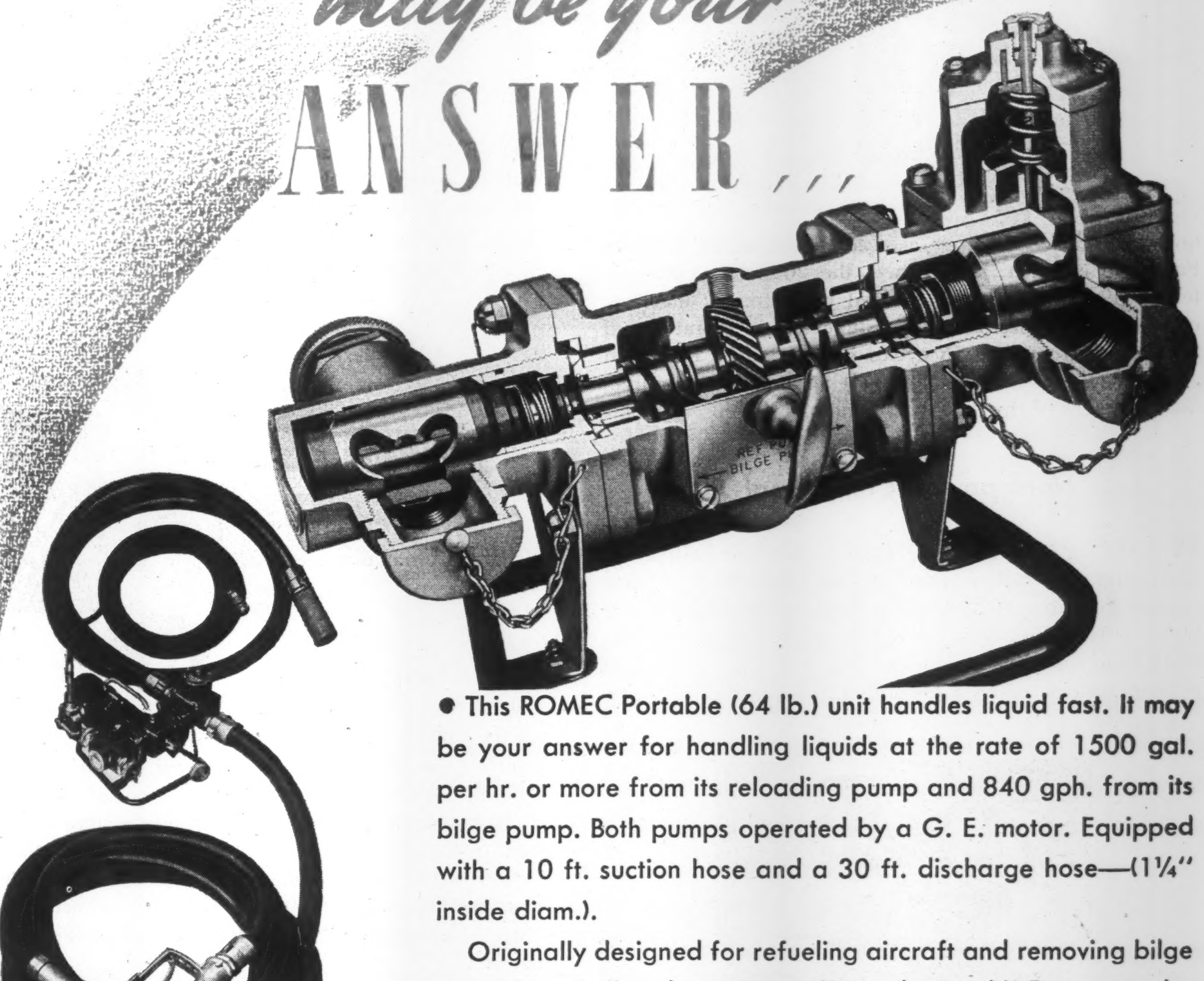
Air Circuit Breaker Offered

DESIGNATED AS Type XRP, a new direct-current, reverse-current, air circuit breaker has been designed by General Electric Co. especially for aircraft use, in accordance with Army Air Force specifications. Rated at 400 amperes, 30 volts, with a reverse-current trip setting of 300 amperes and interrupting rating of 8000 amperes at any altitude from sea level to 50,000 feet, this small and compact breaker is connected in the generator circuit between the generator relay and the positive bus—one being used in the circuit of each generator. The current-

THIS

PORTABLE ELECTRIC-DRIVEN BILGE AND REFUELING PUMP

may be your ANSWER . . .



● This ROMEC Portable (64 lb.) unit handles liquid fast. It may be your answer for handling liquids at the rate of 1500 gal. per hr. or more from its reloading pump and 840 gph. from its bilge pump. Both pumps operated by a G. E. motor. Equipped with a 10 ft. suction hose and a 30 ft. discharge hose—(1¼" inside diam.).

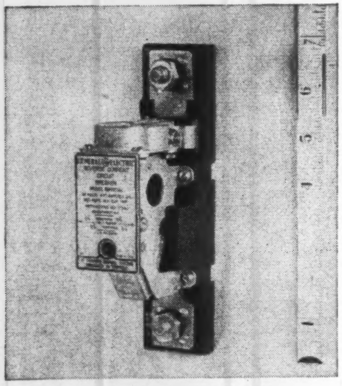
Originally designed for refueling aircraft and removing bilge water from hull and pontoons of sea planes, this Pump may be the answer to liquid handling requirements in your plant. Its easy portability, its precision engineering and high capacity should prove advantageous to you. This is but one of many in the reliable ROMEC line. Write us about your requirements for quick help today.

ROMEC AIRCRAFT PRODUCTS

Romec

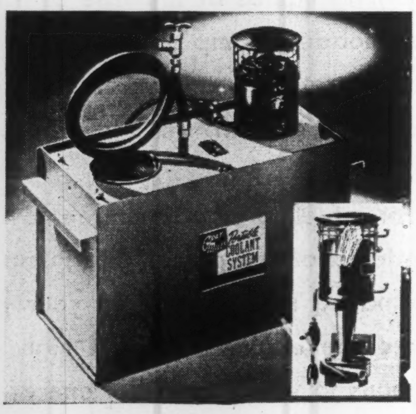
THE ROMEC PUMP COMPANY
101 ABBEY ROAD • ELYRIA, OHIO, U. S. A.

PRECISION PUMP BUILDERS FOR THE U. S. NAVY AND AIR CORPS interrupting capacity is sufficient for use on systems employing up to six 300-ampere generators, and up to three storage batteries. Since the circuit breaker trips on reverse current only, it eliminates false tripping on faults in other parts of the system which draw forward current. It interrupts fault currents in less than 0.015 second, and will operate in a wide range of temperatures, from −65 to 160 degrees Fahr. On a 48-hour test the breaker withstood 95 per cent humidity at 160 degrees Fahr. In addition, it will meet the 200-hour, salt-spray test. The breaker is not affected mechanically in either open or closed position when subjected to vibrations of frequencies from 5 to 55 cycles per second at 1/32-inch amplitude (1/16-inch total travel) applied in any direction. Weight of the unit is 20 ounces.



Low Horsepower Centrifugal Pump

HAVING A CAPACITY of 1200 gallons per hour at no head, and 360 gallons per hour at 5-foot head, a new centrifugal pump of low horsepower has been announced by Gray-Mills Co., 1948 Ridge avenue, Evanston, Ill. This small pump, known as Model 1100, is for use in built-in coolant systems or as a general-purpose pump for sump clean-out, etc. Fluids up to SAE 30 viscosity can be handled, and abrasives or chips do not affect operation as they pass through the pump without binding or abrading. The motor is 1/15-horsepower with sealed bearings, fan-cooled. A universal bracket allows vertical or horizontal mounting or, if desired, the unit may rest on its base of three legs. The motor is connected to the impeller shaft by a tongue-and-groove type coupling.

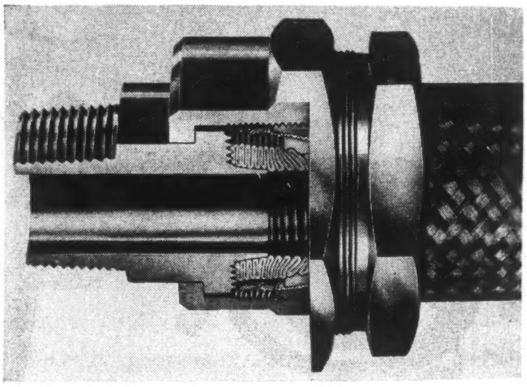


Shims for Adjusting Bearings

VARIOUS TYPES and sizes for individual requirements are available in the new Artus shims produced by Industrial Products Suppliers, 2 Broadway, New York 4. They are impervious to oils and greases, are nonhygroscopic, and maintain the same even thickness under most normal operating conditions. The shims have been approved for all applications where temperatures do not exceed 175 degrees Fahr., and are available for cup-adjusted and cone-adjusted roller bearings.

Detachable Flexible Coupling

OFFERING THE advantage of being mechanically self-sealing, a new detachable brass coupling has been developed by Packless Metal Products Corp., New Rochelle, N. Y., for helical flexible metal hose in sizes from ¾-inch to 1½ inches inside diameter. The unit consists of four parts: The nut, back, stem and split ring. When assembled the convolutions of hose and the metal braid are securely held by pressure between the members, as shown in accompanying illustration. Another feature of the design is the self-contained union which permits the pipe thread end of the coupling to be screwed directly into the machine fitting and the union tightened without twisting hose. The coupling will withstand pressures up to 800 pounds.



Self-Locking Fastener

KNOWN AS TYPE 6NAO, a new triple-grip nut has been added to the line of locknuts and fasteners produced by the Palnut Co., 75 Cordier street, Irvington, N. J. The base of the new nut is similar to the company's standard Palnut with six spring steel jaws fitting the bolt thread. When tightened, the arched, slotted jaws close in around the bolt. Spring tension is also exerted on the bolt threads and downward on the nut base, locking the nut to the bolt. In addition to this, the new nuts

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Designs may be reproduced in any size or number of colors, and can be applied to flat, convex or concave surfaces …even *rubber* and *crinkled* finish. Investigate the amazing variety of uses for Meyercord Decals in every branch of your business. Address Dept. [illegible]

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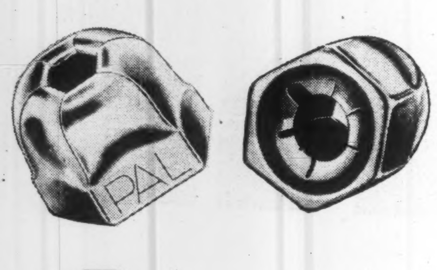
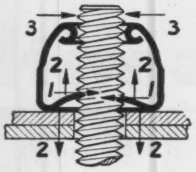
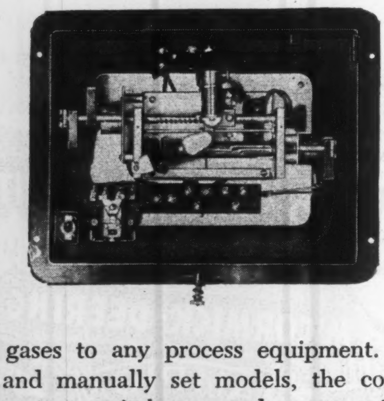
have a third grip which is exerted on the bolt by the top portion of the nut. The sides have been extended up and in, similar to the Acorn Palnut in shape, but instead of a closed top, the ends of the "petals" are turned in, as shown in the accompanying illustration, leaving a hole in the top slightly smaller in diameter than the outside diameter of the bolt. When the bolt extends through the top, it forces it open so that a strong spring pressure is exerted here on the bolt, thus giving the triple grip. Spring tension is constant and will hold the nut in any desired position on the bolt regardless of severe vibration, thus making it useful as an adjustment nut for electrical contacts and mechanical travel units. It may also be used on bolts holding together parts made of glass, plastics and other materials where a resilient fastening is required that can be tightened without danger of fracturing the material to be fastened.



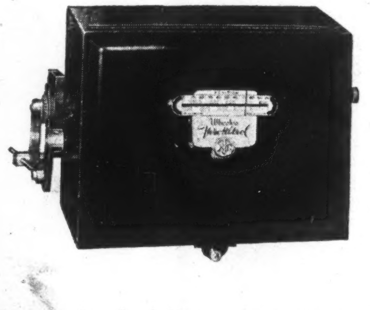


Industrial Controllers Offered

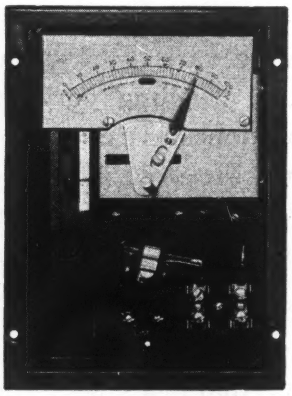
ADDITION OF three new instruments to its line of industrial controllers, and refinements in a fourth, has recently been announced by Wheelco Instruments Co., Chicago 7. Two of the new instruments, known as Inputrols, are designed to control input of power, heat of flow of liquids or gases to any process equipment. Offered in automatic and manually set models, the controller consists of a mercury switch mounted on a carriage, a rotating horizontal cylindrical cam driven by a small synchronous motor, and a spiral on which the mercury switch carriage is mounted. In the automatic model, used with a pyrometer, the spiral is turned automatically to position the switch carriage at the proper point along the rotating cam, while in the manual model it is set by hand. The Inputrol is illuminated, and may be flush or surface mounted.



The Throttltrol is designed to correct variations in heat requirements of furnaces and process equipment by positioning a valve in the fuel line. At a given setting it will permit a fuel valve to open only the desired distance when the two-position control instrument is in its "On" position. In this manner an even and constant flow of fuel to the burner is maintained, minimizing the danger of "overshooting".



The last of the new controllers is the manually-operated Rheotrol for regulating input to electrically-operated furnaces, ovens, heaters, kilns, etc. Offered in a new flush-mounted case, the instrument replaces the standard rheostat and, by eliminating current waste through resistors, provides improved operating efficiency.

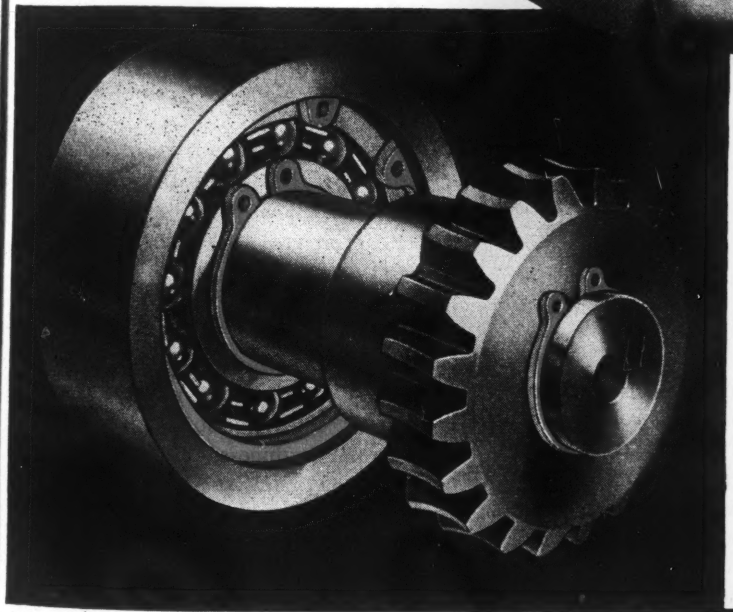


Miniature Frequency Meter

MEETING THE ASA C39.2—1944 specifications for electrical indicating instruments in depth of case and mounting dimensions, the new Model 21-FX miniature frequency meter introduced by J-B-T Instruments Inc., 441 Chapel street, New Haven 8, Conn., supersedes the company's Model 21-F. Because the new model is more compact, it can be used for airborne units, portable equipment and miniature panel boards. Only one clearance back of panel has to be figured, and drilling operations and hardware are on the panel, making for fast assembly. While weight has been reduced, accuracy remains ±.2 per cent or ±.3 per cent. No adjustment while in service is necessary on these vibrating-reed frequency meters.

WALDES TRUARC RETAINING RING

U. S. Patent
Re 18144



For thrust-load fixing, and shaft and housing applications, Waldes Truarc provides distinct advantages over nuts and bolts or wedges and washers... it reduces dimension and weight... saves material... cuts manufacturing time... simplifies assembly and dis-assembly.

On request, we will gladly furnish samples and full data for your tests.

Waldes Truarc presents a significant advance in retaining rings.

It spreads or contracts without distortion; always retaining its perfectly fitting circular contour.

INTERNAL TYPE
NATIONAL AIRCRAFT
STANDARD
50

EXTERNAL TYPE
NATIONAL AIRCRAFT
STANDARD
51

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WALDES KOH • I • NOOR • INC. ★ LONG ISLAND CITY, N. Y.

Canadian Representatives: Prenco Progress and Engineering Corp., Ltd., 72-74 Stafford St., Toronto

Frank P. Bleier

Raymond F. Pfautsch

Alex D. Bailey

MEN . . . of . . . machines

FRANK P. BLEIER, who has been research and development physicist for Ilg Electric Ventilating Co., has been named director of the company's new research laboratory. Mr. Bleier is a graduate of the Technical University of Vienna, Austria, in applied mechanics and physics, and is considered an authority in the field of fan design based on the theory of aerodynamics. Since he has been connected with the company he has worked closely with officials in the United States Navy and Maritime Commission developing special marine ventilating apparatus. His most outstanding achievement for the war effort is his design of a complete line of axial-flow fans, now used by the marine industry but scheduled for general use after the war.

RAYMOND F. PFAUTSCH—another member of the engineering department of the Ilg Electric Ventilating Co.—has been appointed assistant chief engineer. Formerly he had been an engineer assigned to new product design. In his new capacity he will continue to devote his time primarily to product development and manufacture. A graduate of the University of Illinois with a degree in mechanical engineering, Mr. Pfautsch has been associated with the Ilg organization for the past fifteen years. He has been a member of the American Society of Mechanical Engineers for some time.

ALEX D. BAILEY, nominee for president of The American Society of Mechanical Engineers, is vice president in charge of operations and engineering of the Commonwealth Edison Co., Chicago. Mr. Bailey received his degree in mechanical engineering in 1903 at the Lewis Institute, and an honorary degree of doctor of science was accorded him by the Northwestern university in 1942. Immediately upon graduation in 1903 Mr. Bailey entered the employ of the Commonwealth company, and progressed successively through the positions of chief engineer, superintendent of generating stations, chief operating engineer, assistant to president, and since July of this year, vice president. He has contributed to many improvements in the design and operation of special equipment, and to advances in operating practices throughout this period. Being a member of the

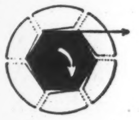
The screw that's Built like a Gear

to give you faster, easier, tighter fastenings—especially where vibration is a factor
THE STRONGEST
SMALL SCREW ON THE MARKET

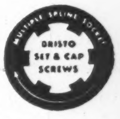
A sound engineering principle makes Bristo Multiple-Spline Socket Set Screws your safest recommendation for protection against vibration.

This screw can be set up tighter than any other . . . for the spline design *pulls* the wrenching force *inward,* not outward. It can be turned far beyond the point where an ordinary screw would burst or at least round out to stop effective wrenching. Yet a flick of the key will loosen it for quick removal!

Any assembly man will thank you for specifying Bristo. Assembly is easier, faster, especially when the fastening point is hard to reach—the splines in the screw cling to the splines on the wrench.



Hex: key exerts outward pressure against socket wall; screw will round out or break.



Bristo: key exerts *inward* pressure; no danger of rounding out or breaking socket wall.

And the man who buys and uses your product will be grateful for the stronger fastening. Because Bristos—no matter how small (even down to the No. 4 wire size)—have greater strength, will hold more tightly, than other screws of comparable size.

TYPICAL APPLICATIONS

- cameras
- radio assemblies
- computing machines
- electric shavers
- scientific instruments
- x-ray machinery
- electric refrigerators
- motor assemblies
- vacuum cleaners
- domestic appliances

See THOMAS' REGISTER for more facts, list of product applications. Remember Bristo for vibration conditions.

The BRISTOL Company
MILL SUPPLY DIVISION

BRISTO MULTIPLE SPLINE SOCKET SET **SCREWS**

Geared to the Key—for faster, easier, tighter setting

ARMY E NAVY

THE BRISTOL COMPANY, [illegible] BRISTOL ROAD, WATERBURY 91, CONNECTICUT

American Society of Mechanical Engineers since 1910, Mr. Bailey has had a keen interest in its advancement, and has held many offices. He is still active on a number of standing committees which concern either research or education and training.

◆

R. G. WINGERTER has recently been appointed assistant chief engineer of the Industrial division, The Timken Roller Bearing Co. Mr. Wingerter, who holds a bachelor of science degree in mechanical engineering from Wayne university, has been an industrial engineer with Timken for the past six years.

◆

ALLEN B. DU MONT was awarded the honorary degree of doctor of engineering at the 120th commencement exercises of Rensselaer Polytechnic institute. Mr. Du Mont, president of the Allen B. Du Mont Laboratories Inc., Passaic, N. J., was cited particularly as "a pioneer in the development and use of the cathode-ray tube which today is the heart of the weapon, radar".

◆

C. F. GRAFFLIN, formerly technical assistant to the general manager of the Aircraft and Engine division, Embry-Riddle Co., Miami, Fla., is now engine specialist for Dade Drydock Corp., of the same city.

◆

GEORGE THARRATT, formerly chief engineer of Adel Precision Products Corp., Burbank, Calif., is now general manager of Lear Avia Inc., Los Angeles.

◆

DONALD W. MCGILL succeeds L. F. A. MITCHELL as manager of the machinery electrification section of the industrial department of Westinghouse Electric & Mfg. Co. Mr. Mitchell has returned to the Canadian Westinghouse company as assistant to the vice president.

◆

JOSEPH S. BENNETT, who has served the American Engineering Co., as draftsman, assistant construction engineer, assistant mechanical engineer and manager of sales, has been appointed vice president of the company. Mr. Bennett received his B.S. in M.E. from the University of Pennsylvania, and is author of many papers on technical subjects. He holds 31 patents in the United States and a total of 106 including foreign countries.

◆

HAROLD W. SCHAEFER, as assistant manager of the newly-formed Radio Receiver division of Westinghouse Electric & Mfg. Co., will be in charge of engineering and production activities. Mr. Schaefer brings to his new post a background of more than eighteen years of radio and other household equipment engineering and production management experience.

◆

DR. ZAY JEFFRIES, noted scientist and pioneer in tungsten metallurgy and in the development of high-strength aluminum alloys, has been elected to the board of trustees of Battelle institute.

◆

G. G. CUDHEA, formerly assistant chief engineer, has been made chief engineer of Fleetwings Division, Kaiser Cargo Inc. Mr. Cudhea, who has been with the company since 1937, began as chief of structures and became successively chief production engineer, executive engineer and assistant chief engineer. G. S. THOMPSON, chief design engineer, has been named assistant chief engineer, succeeding Mr. Cudhea, while G. NONINI is now chief production engineer in charge of all production design and liaison.

◆

C. W. LA PIERRE has been appointed assistant engineer of the General Electric Co. general engineering laboratory. Since 1936 he has been in charge of the electromechanical sections of the laboratory, which he joined when becoming connected with G-E in 1924. Mr. La Pierre has fifteen patents in his name covering measurements and electronic circuit applications.

◆

DR. EDWARD U. CONDON, associate director of the Research Laboratories, Westinghouse Electric & Mfg. Co., has been elected to membership in the National Academy of Sciences.

◆

STERLING SMITH, since 1941 chief of the refrigeration and air conditioning section of the general industrial equipment division of the WPB, has recently resigned. He will assume the managership of the commercial refrigeration division of Mills Industries, Chicago.

◆

JAMES R. LONGWELL has recently been made director of engineering and research at Carboloy Inc. During the fifteen years he has been with the company he served successively as development engineer, chief engineer and factory manager.

◆

MICHAEL J. ROSS has joined the Harnischfeger Corp., Milwaukee, as mechanical engineer. He had previously been in the engineering department of the Crane Co.

◆

MILO M. DEAN, previously executive engineer for Douglas Aircraft Co. Inc., has become associated with Greyhound Corp., Chicago, as chief engineer.

◆

PAUL H. SETZLER, who has had several years of engineering background in the field of welding, has become connected as consulting engineer with the engineering staff of the United Welding Co., Middletown, O.

◆

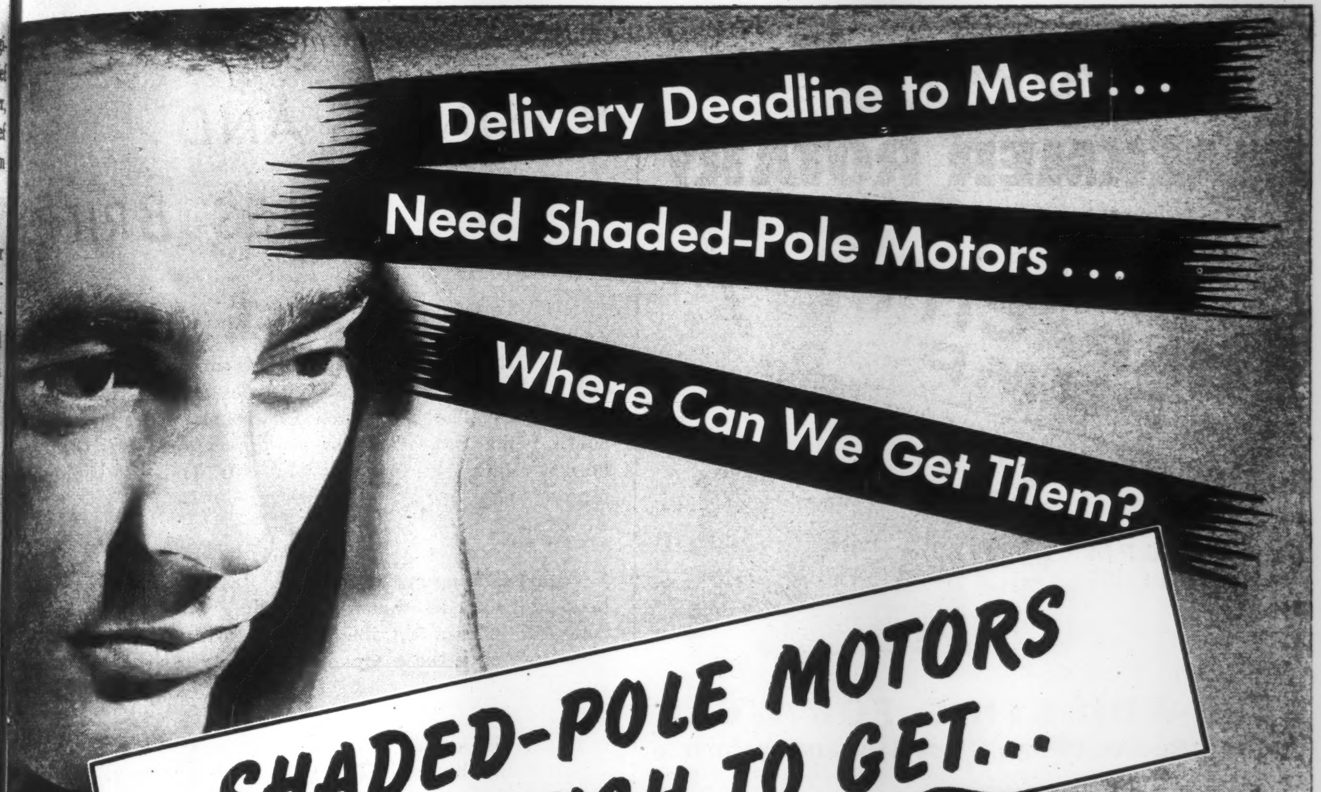
JOSEPH B. ENNIS, senior vice president of the American Locomotive Co., has been awarded the George R. Henderson medal by the Franklin institute "in consideration of his accomplishments in locomotive engineering and important contributions in the field of locomotive design."

◆

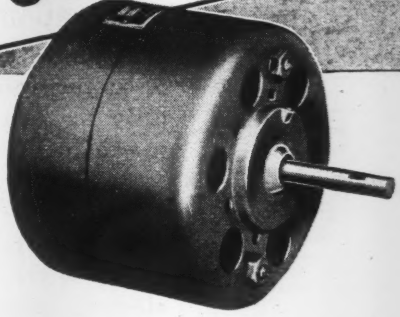
GEORGE M. LANGE, formerly an engineer with Timken Roller Bearing Co., is now working on fuel injection equipment with Ex-Cell-O Corp.

◆

G. W. BAIERLEIN has been appointed mechanical engineer for Chandler-Evans Corp., South Meriden, Conn., where he is technical assistant to the vice president of engineering. Mr. Baierlein's previous experience includes that of chief designer of Hub Industries Inc., and before that twelve years with the American Bosch Corp.


Delivery Deadline to Meet . . .
Need Shaded-Pole Motors . . .
Where Can We Get Them?

SHADED-POLE MOTORS *ARE* TOUGH TO GET...



. . . but fortunately for you and many manufacturers in urgent need of such motors, we have managed (even in the face of tremendously increased demands) to maintain a reliable production and delivery schedule on certain types of Pilot Shaded-Pole Motors.

So, if you are in need of Shaded-Pole Motors, write us today telling us about your requirements and we will help you to the best of our ability. You can count on that!

Pilot Shaded-Pole Motors are available in types for continuous or intermittent duty with H.P. ratings ranging from 1/15 to 1/500 and from 1550 to 3400 R.P.M. Plain round or with base or resilient mounting . . . open or enclosed cases.

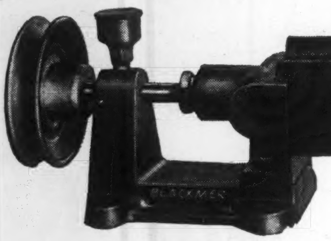
F. A. SMITH MFG. CO., INC.

401 DAVIS STREET, ROCHESTER 5, N.Y.

FASCO

Pilot
Shaded-Pole
MOTORS

NEW
BLACKMER ROTARY
SMALL CAPACITY PUMP



2/3 to 3-1/2 G P M
Pressures to 150 psi.

SELF-ADJUSTING FOR WEAR
due to "Bucket Design" (special vane) principle

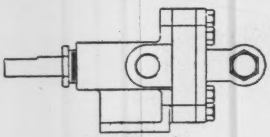


Fig. 1502 Pump only.

AS PUMP ONLY
Complete with casing or as pumping element only for use as part of machine.

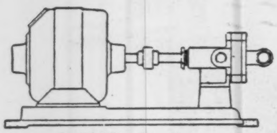


Fig. 3503 Motor Drive Unit.

POWERED UNIT
A complete pumping unit with base and electric motor.

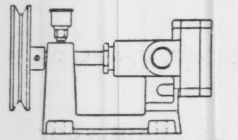


Fig. 2502 V-Belt Drive Unit.

V-BELT DRIVE
This unit is furnished complete as shown.

Small size, quiet operation and wide choice of mountings and drives gives this new pump many industrial applications. It is designed to handle oils, solvents, hydraulic control liquids and all clean liquids having lubricating properties.
This pump can be furnished in special construction for mounting on many different types of machines. Please send us your specifications.

SPECIAL RELIEF VALVE OPTIONAL

Write for mounting diagrams and specifications. Bulletin NEW 2.

OTHER BLACKMER UNITS:
POWER PUMPS; HAND PUMPS;
EZY-KLEEN STRAINERS;
Capacities 1 to 750 GPM

BLACKMER PUMP COMPANY
19710 CENTURY AVE. GRAND RAPIDS 9, MICHIGAN

BUSINESS AND SALES BRIEFS

APPOINTMENT of Harold C. Olson as sales manager and John A. Toth as assistant sales manager has been announced by The Torrington Co., Bantam Bearings division, South Bend, Ind. Prior to his appointment Mr. Olson had been assistant sales manager while Mr. Toth had been special representative in the steel industry.

*

With headquarters at Reading, Pa., Lloyd W. Hopkins has been named sales manager, Reading Steel Casting division, American Chain & Cable Co. Inc. Mr. Hopkins has been associated with the company for twenty-one years.

*

Under the direction of sales manager C. R. Terry, new regional and branch office sales headquarters at 717 Hanna building, Cleveland 15, have been established by The Hydraulic Press Mfg. Co., Mount Gilead, O. With Paul E. Flowers as branch office manager for metropolitan Cleveland, the new office will serve northeastern Ohio, western New York and western Pennsylvania.

*

Formation of the Machine Tool Welding division at 19351 John R street, Detroit 5, has been announced by Wall-Colmonoy Corp. of Detroit, manufacturers of hard-facing alloys and overlay metals.

*

Adel Precision Products Corp. has named George R. Pizarro as manager of the new engineering service office located at 630 Fifth avenue, Rockefeller Center, New York, and has appointed J. H. Bourdon as manager of the new engineering service office in Baltimore.

*

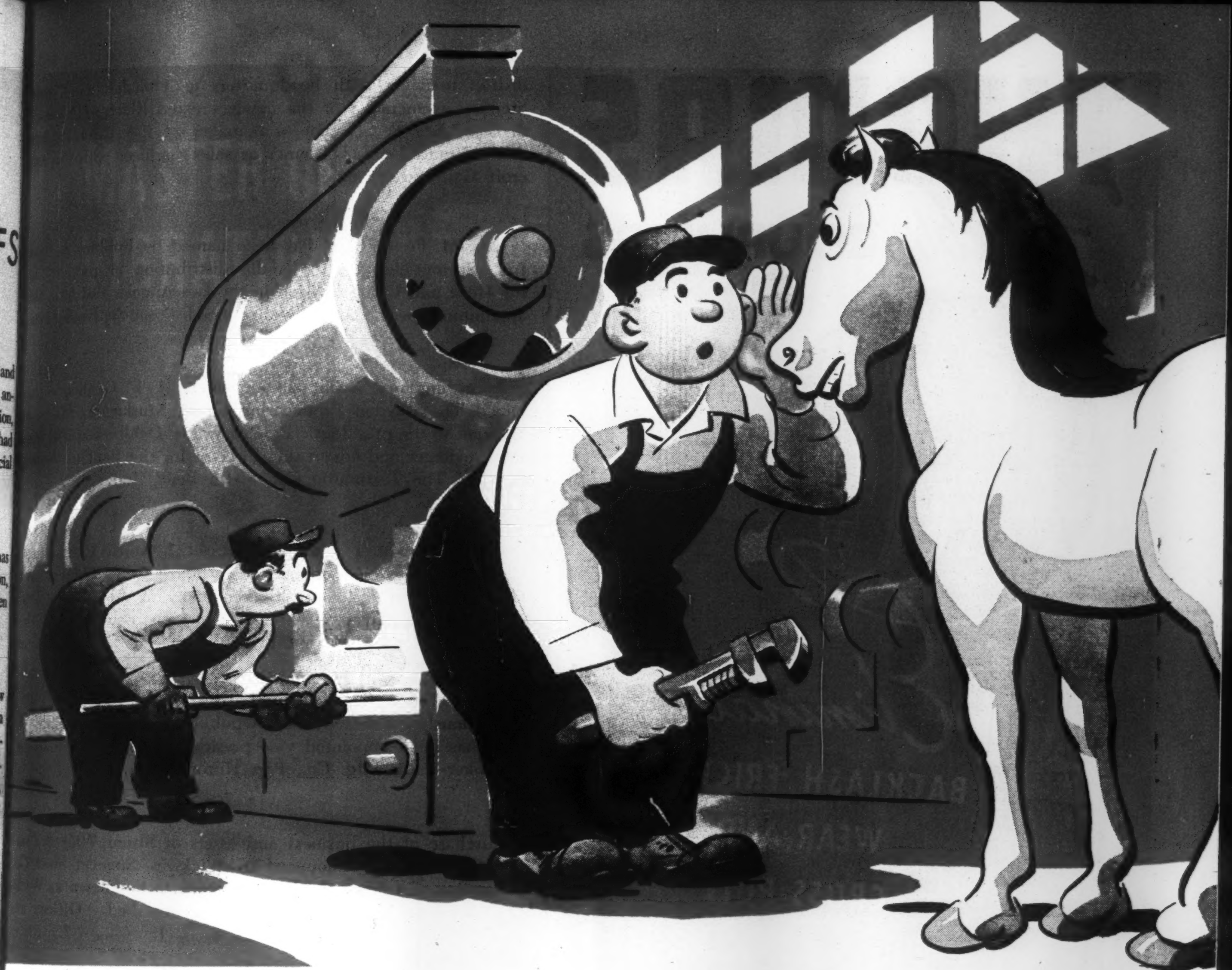
Moving of the Eastern sales office from Room 1310 Fisk building, 250 West Fifty-seventh street, New York, to Room 660 Industrial Office building, 1060 Broad street, Newark 2, N. J., has been announced by John S. Barnes Corp. E. C. Hawkins will remain in charge of sales in the Eastern territory.

*

G. F. Golby has been named manager of the Toronto, Canada, branch office and warehouse of Jessop Steel Co., Washington, Pa. Mr. Golby had been with Crucible Steel Co. for the past fourteen years.

*

Associated with the company for twenty-three years, Albert W. Coleman has been given the newly created position of sales manager for Manning, Maxwell & Moore Inc., Bridgeport, Conn., and will make his headquarters at Bridgeport. Replacing Mr. Coleman as Pacific Coast district manager is Paul M. Rolli, former representative on the coast. Other appointments include that of L. E. Gebhart as Mid-Atlantic



Don't Be Fussin' and Fixin'—Get Horsepower by Howell

REPAIR MAN: I'd like to wrap this wrench around the guy's neck who insulated this motor.

HORSE: I know how you feel about sloppy work.

REPAIR MAN: Here we are at the peak of production, and what happens? Motor failure . . . tear down the machine . . . lose time . . . get behind — all because the motor wasn't built right in the first place.

HORSE: My good man, stop worrying! Use Howell Motors. The entire stator of every Howell Motor is triple-treated with Howell Bond varnish. It is made to withstand temperatures up to 350° F.— is water and oil proof and grease resisting, and it will not break or crack. The rotors are copper, too, and the best grade bronze or ball bearings are used. You just can't buy better motors.

REPAIR MAN: That's right! I know it! I'm specifyin' HOWELL for all my new jobs.

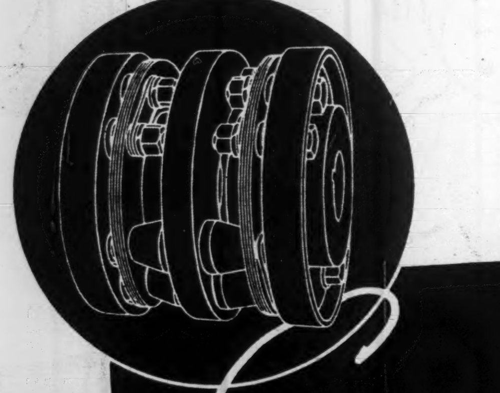
Phone the nearest Howell representative today, or write direct to the factory for prices, data and delivery dates on Howell standard or specialized motors for every industry, up to 150 Hp.

HOWELL ELECTRIC MOTORS COMPANY
HOWELL, MICHIGAN
Manufacturers of Quality Motors Since 1915

The Howell Protected Type Motor, shown, gives complete protection against dripping liquids, metal chips and other falling particles. Completely streamlined — utilizing non-breakable steel frame — malleable or steel base — cast iron end plates and cast iron, weatherproof terminal box are standard construction features. Special horizontal and vertical mountings are available.

Available in sizes 5 H.P. and smaller.

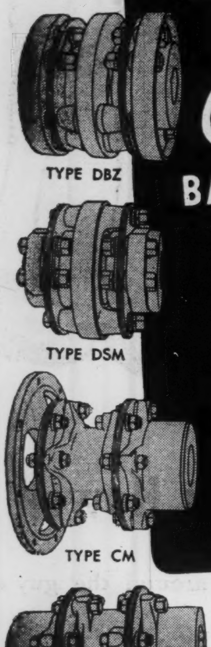
THOMAS *Flexible* COUPLINGS



Eliminate:

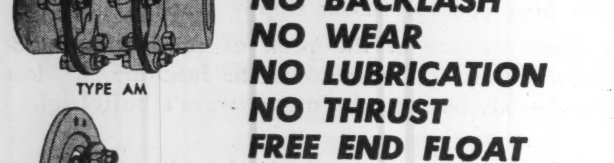
BACKLASH, FRICTION, WEAR AND CROSS-PULL

the four destructive evils found in other types and makes of couplings.



NO BACKLASH
NO WEAR
NO LUBRICATION
NO THRUST
FREE END FLOAT

These are the five essential features of Thomas Flexible Couplings that insure a permanent carefree installation.



WRITE FOR COMPLETE ENGINEERING CATALOG

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

district manager with headquarters at Philadelphia, Charl Stephan as manager of the newly created Electro-Mechanic division, Lee P. Stillman as manager of the Tulsa Produc division, and James O'Connor as sales engineer with the As croft Gauge division.

⁂

Geo. M. Prescott Co. has been named by Robbins & Myer Inc., Springfield, O., to handle distribution of products fo the Hoist and Crane division in the Los Angeles district. Th appointment was incorrectly announced in our September issue

⁂

According to a recent announcement, J. F. Oehlhoffen ha joined The Kaydon Engineering Corp., Muskegon, Mich., a assistant to the president. Previously Mr. Oehlhoffen had bee sales manager and advertising director for the Bantam Bearin division, The Torrington Co., South Bend, Ind.

⁂

Completion of a new plant at 4427 North Clark street Chicago 40, has been announced by Merit Coil & Transforme Corp. General offices of the company at 311 North Desplaines street will soon be moved to the new plant. Also announced is the appointment of John I. Crockett Jr. as sales manager.

⁂

Previously connected with Republic Steel Corp., Elmer W. Pfeil has been appointed vice president and general manager of Anker-Holth Mfg. Co., Port Huron, Mich.

⁂

Purchase of the business and assets of Sirian Wire & Contact Co. has been announced by Wickwire Spencer Steel Co. Formation of a new subsidiary company to be known as Wickwire Spencer Metallurgical Corp. has resulted. Offices are at 260 Sherman avenue, Newark 5, N. J.

⁂

Formerly manager of the production department of The International Nickel Co., A. J. Hanlon of New York has been named production manager of Harvill Corp., Los Angeles 43.

⁂

Addition of Paul Torre to the staff of sales engineers covering the New England territory has been announced by The Foxboro Co. Mr. Torre will make his headquarters at the district office in Foxboro, Mass.

⁂

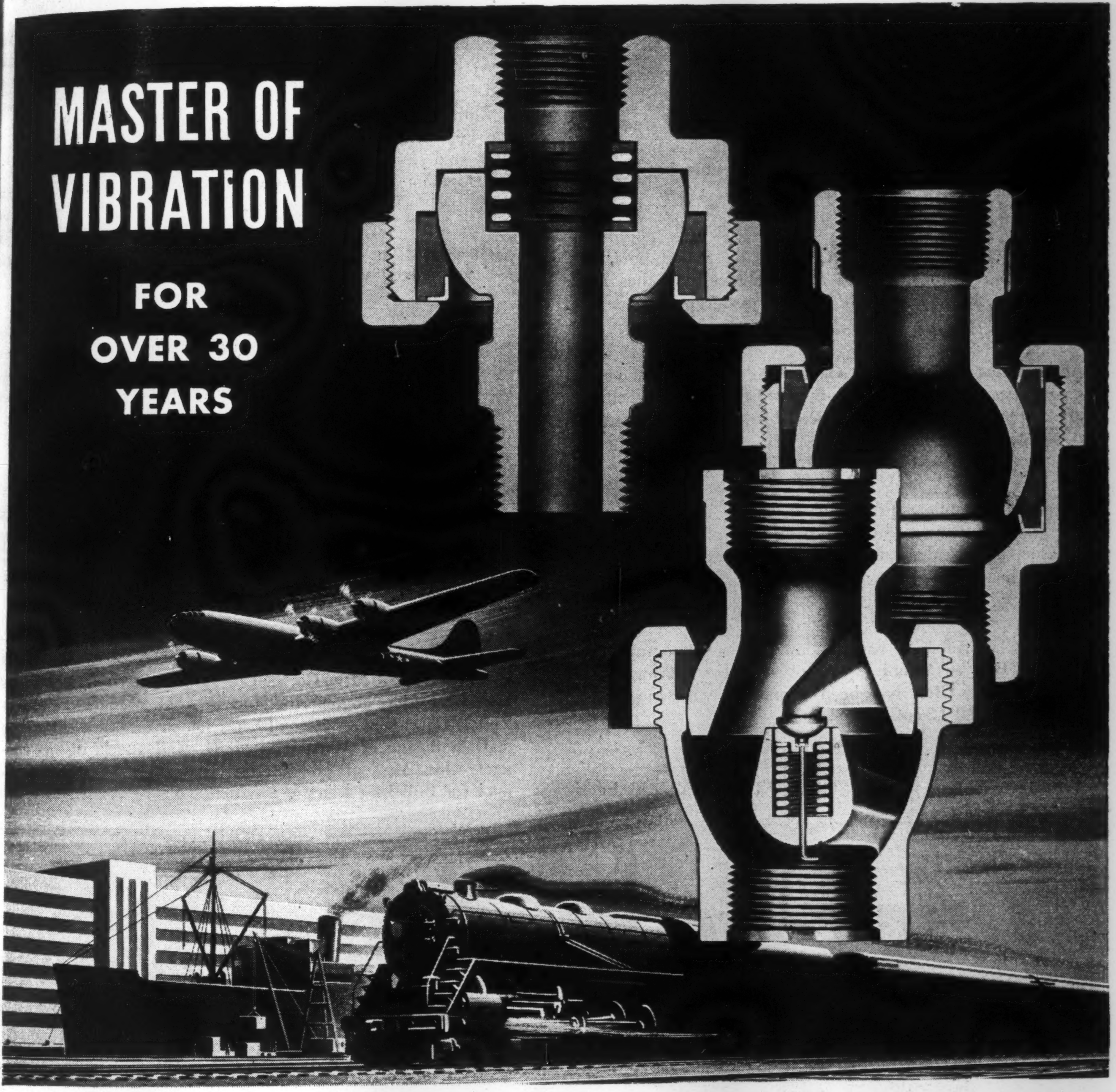
Reopening of branch offices in Chicago and Los Angeles has been announced by Pressed Steel Tank Co., Milwaukee. Kenneth Cole has been placed in charge of the Chicago office at 208 South LaSalle street while James Barr will manage the Los Angeles office at 727 West Seventh street.

⁂

Logansport Machine Co. Inc. has announced that Walter Ellis, former chief sales engineer, has become associated with Compressed Air Products, sales representatives for the company in the Newark, N. J., territory.

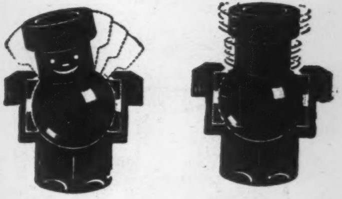
⁂

The Ohio Crankshaft Co., Cleveland, has appointed The Anderson Machine Tool Co. at 2645 University avenue, St. Paul 4, as a special distributor of Tocco process induction equipment to serve the Wisconsin-Minnesota area. Also announced is the appointment of R. L. Willis as a sales engineer of the Tocco process induction heating division. Previously



The Barco Flexible Joint—in a complete range of designs for transportation and industrial needs—has long been the accepted standard of reliability in connections for fluid-conveying pipes. Providing responsive movement through every angle, a Barco Flexible Joint absorbs vibration and compensates for expansion and contraction. The broad experience and exact technical skill of our engineering department is available to you on request. Barco Manufacturing Company, Not Inc., 1806 Winnemac Avenue, Chicago 40, Illinois.

In Canada: The Holden Co., Ltd., Montreal, Canada



"MOVE IN EVERY DIRECTION"

Not just a swivel joint...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

BARCO *FLEXIBLE JOINTS*

THE FREE ENTERPRISE SYSTEM IS THE SALVATION OF AMERICAN BUSINESS

assistant manager of sales at the structural and bar division of The Weirton Steel Co., Mr. Willis will work out of the Chicago office of the Ohio Crankshaft Co.

•

According to an announcement by The Midvale Co., Nicetown, Philadelphia 40, Howard M. Givens Jr. has been made manager of bar steel sales and will make his headquarters in Philadelphia.

•

Purchase of Fort Pitt Steel Casting Co., McKeesport, Pa., manufacturers of pressure and alloy steel castings, has been announced by H. K. Porter Co. Inc. of Pittsburgh, Pa.

•

Appointment of Robert S. Clingan as general manager of sales has been announced recently by Copperweld Steel Co., Warren, O. Until his appointment Mr. Clingan had served as Chicago district manager.

•

Succeeding the late Francis P. Gormely is E. E. LeVan as president of Haynes Stellite Co., a unit of Union Carbide & Carbon Corp. Mr. LeVan will continue to be located at company headquarters in Kokomo, Ind.

•

Hycar Chemical Co. has announced the appointment of Frank E. Bell as technical service engineer. Prior to his appointment Mr. Bell had been connected with the Barrett division of Allied Chemical & Dye.

•

With headquarters at Room 1101 First National Bank building, Canton, O., M. M. Clark has joined Climax Molybdenum Co., New York, as metallurgical engineer in the Ohio district.

•

Formation of Devenco Inc. at 150 Broadway, New York 7, has been announced by Theodore J. Kauffeld, J. Q. A. Holloway and James J. Ryan. The new company will render development engineering service.

•

According to a recent announcement, Dunn Engineering Co. has moved to 6341 Lyndon avenue, Detroit 21.

•

J. Harry DuBois has been named executive engineer for Shaw Insulator Co., pioneer molder of plastics materials specializing in the development of new methods for the fabrication of plastics. Formerly commercial engineer for the Plastics division of General Electric Co., Mr. Dubois will assist Frank H. Shaw, president, and act as plastics consultant.

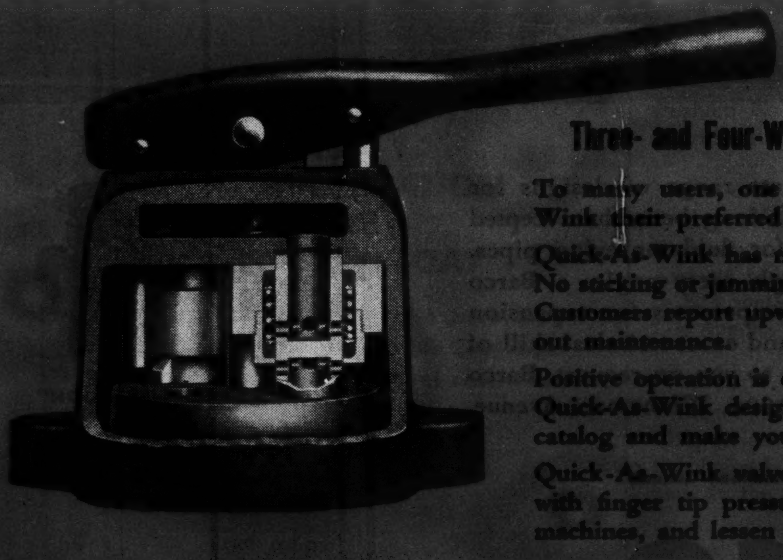
•

Election of Arthur M. Morgan as a director has been announced by Latrobe Electric Steel Co., Latrobe, Pa. Mr. Morgan is vice president in charge of sales with offices in Pittsburgh.

•

Formerly connected with the Electrical division of Colt's Patent Firearms Mfg. Co. in Chicago, Frank D. Popowics has joined the sales engineering staff of Allen-Bradley Co. in New York. Charles M. McCoombs has joined the sales engineering staff in Boston as assistant to M. H. Hallenbeck, district manager. Mr. McCoombs had been New England district manager for Bull Dog Electric Products Co.

Quick-As-Wink . . . CONTROL VALVES



Three- and Four-Way Hand Operated Control Valves

To many users, one single advantage makes Quick-As-Wink their preferred valve.

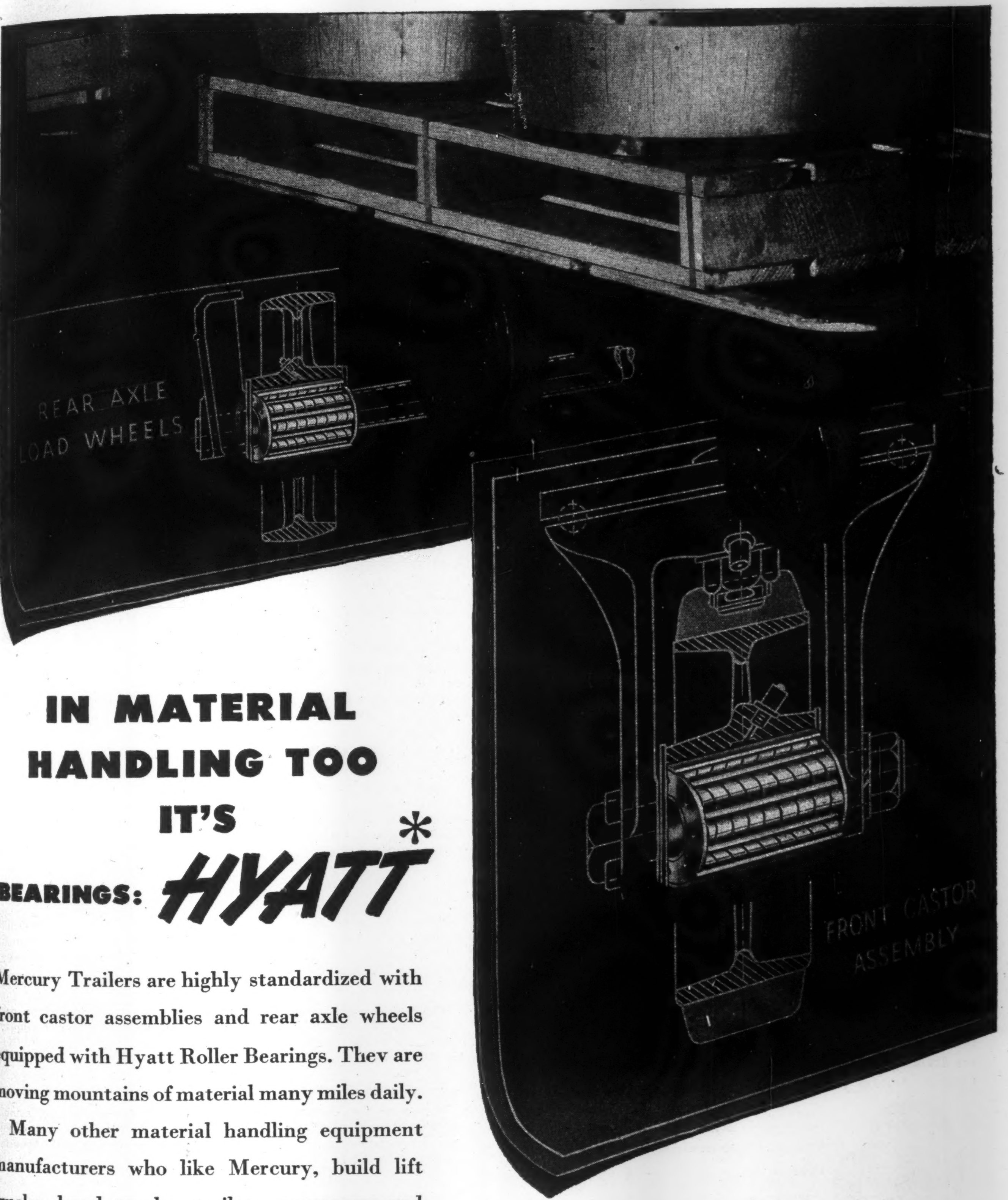
Quick-As-Wink has no moving parts to get out of order. No sticking or jamming or mechanical trouble of any kind. Customers report upwards of 50,000,000 operations without maintenance.

Positive operation is only one of many advantages of the Quick-As-Wink design. Send for our informative, factual catalog and make your choice.

Quick-As-Wink valves are fast, operate with finger tip pressure, speed up your machines, and lessen operator fatigue.

THE HIGHER THE PRESSURE
AIR
WATER
OIL
THE TIGHTER THE SEAL

C.B.HUNT & SON
1854 E. Pershing St. *Salem, Ohio*



IN MATERIAL HANDLING TOO IT'S BEARINGS: HYATT*

Mercury Trailers are highly standardized with front castor assemblies and rear axle wheels equipped with Hyatt Roller Bearings. Thev are moving mountains of material many miles daily.

Many other material handling equipment manufacturers who like Mercury, build lift trucks, hand trucks, trailers, conveyors and cranes, recognize their customers' desires for value, long service and reduced maintenance by also standardizing on Hyatt Roller Bearings.

* *For these and other applications with a complete line of wound and solid roller bearings, Hyatt engineers will gladly advise on your problems.*

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION

HARRISON, NEW JERSEY • CHICAGO • DETROIT • PITTSBURGH • OAKLAND, CALIFORNIA